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Spaceflight

The International Magazine of Space and Astronautics

Astronauts in Action

Featuring:

European Programmes

Shuttle Mission STS-61

Rescue and Return

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International Space Station

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In the perspective of a single composite mission, this documentary illustrates the major accomplishments of the Gemini two-man space flights and the significance of these flights to the Apollo Program. The film includes outstanding photography of the Earth and man in space. *28 mins*

Apollo Missions 4, 5 and 7

Apollo 4 Mission: Covers the launch of the mighty Apollo/Saturn V unmanned space vehicle which reached an altitude of 11,232 miles. As Apollo 4 climbs toward this peak altitude, a camera pointed out the spacecraft window, records views of the Earth. The Service Module propelled the Command Module into reentry velocity of approximately 25,000 miles per hour. *15 mins*

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Flight of Apollo 7: Records life and work on the first manned flight of the Apollo series. Apollo 7 was designated to make the essential test of the Apollo spacecraft before the ambitious lunar-orbital mission could be attempted. All systems respond perfectly. The first television from space highlights the film. *14.5 mins*

Total running time 46.5 mins

Apollo 8: Go For TLI

This Saturn V flight was man's first journey around the Moon and forerunner of the Apollo lunar-landing flights. The three-man crew (Borman, Lovell and Anders) set course for the Moon, passed behind it and transferred to a lunar orbit, circling the Moon ten times in 20 hours. Their many still photographs and much cine film helped to decide on landing sites for later missions. The final TV transmission took place while 97,000 miles from Earth. *22 mins*

Apollo 9: Three to Make Ready

Building on the successful flight of Apollo 8, a lunar module was tested in space, as was the life support system of the space suit. Two of the three-man crew (McDivitt, Scott and Schweickart), transferred to the Lunar Module, moved 100 miles away from the Command Module and then returned to rendezvous with it. The two men then transferred back to the Command Module and the Lunar Module was jettisoned. *17 mins*

Apollo 10: To Sort out the Unknowns

Lift-off to a trans-lunar orbit by Stafford, Young and Cernon, with views of Earth and system checks *en route*. There was loss of communications signal while passing behind the Moon as the craft transferred to lunar orbit. Signal acquisition returned when the spacecraft reappeared, with TV pictures showing the Lunar Excursion Module (LEM) undocked from the Command Module and descending to within 50,000 feet of the lunar surface. Direct communications between Control and LEM failed so access was made *via* the CM. LEM subsequently rendezvoused with the CM, the crew transferred again and LEM was jettisoned. *26 mins*

Mission of Apollo Soyuz

In July 1975 spacecraft from the Soviet Union and the United States blasted off on an historic mission. Two days after blasting off Apollo and Soyuz docked high above the Atlantic Ocean. This NASA film covers the scientific and technological achievements of the mission and stresses the spirit of cooperation and friendship. *28.5 mins*

STS-46: Mission Highlights

This features the 12th flight of Atlantis with a crew of seven. Flight objectives included the deployment of the European Recoverable Satellite (Eureca) using the Robot Arm operated by Mission Specialist Claude Nicollier and the first, though unsuccessful, launch of a Tethered Satellite. *50 mins*

STS-54: Mission Highlights

The flight of Endeavour with a crew of five features splendid scenes of the launch of theTracking and Data Relay Satellite (TDRS) against an Earth backdrop and experiments with Biopack. Onboard crew activities include a variety of physical exercises. The video concludes with spectacular EVA and Earth shots. *50 mins*

STS-49 Mission Highlights

The details of this flight by the Shuttle Endeavour, 7-16 May, 1992, are well covered, e.g. the preliminaries of suiting-up, the White Room, entry to orbiter, removal of gantry, count-down, engines start, lift-off, and detailed operations during the flight. A principal aim was to retrieve the Intelsat VI satellite which had previously failed to reach synchronous orbit. Though more difficult than expected, it was achieved and sent on its way. A second aim was to practice basic space station assembly work by Extra-Vehicular Activity (EVA). This was also very successful. The video concludes with an interesting press interview with the crew. *1hr 50 mins*

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Spaceflight

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Space Policy

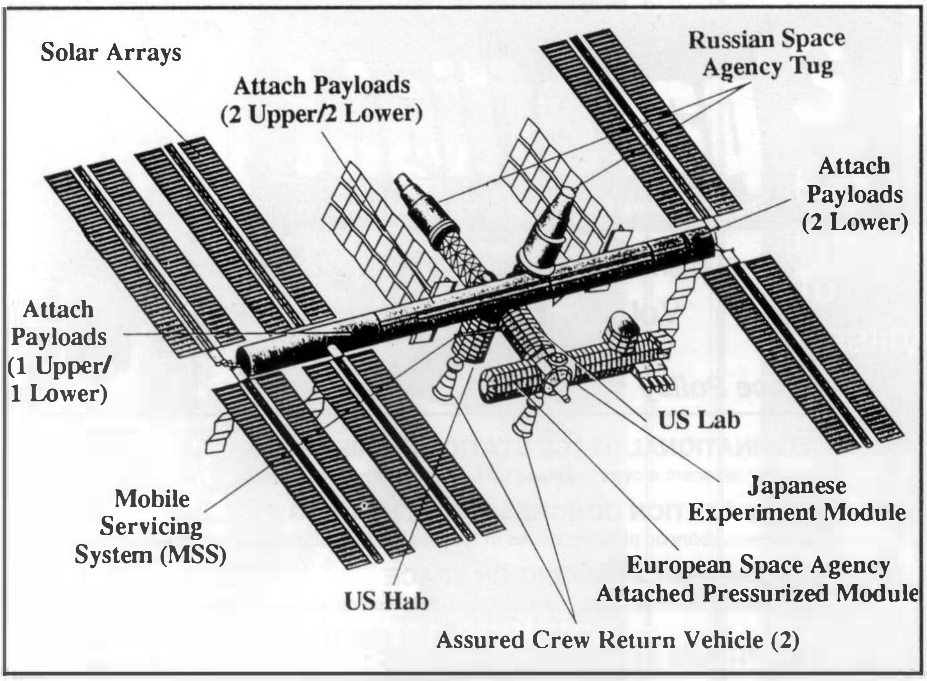
Astronauts In Action

Features

News & Events

Space Miscellany

Front Cover: **Astronauts Richard J. Hieb, Thomas D. Akers and Pierre J. Thuot move the captured Intelsat VI communications satellite into Endeavour's cargo bay during the STS-49 mission in May 1992. See p. 48.**
NASA



International Space Station Project

This new and latest plan for an International Space Station is divided into three stages. During the first stage, Russian and American teams will work together using the existing orbital station Mir and the Space Shuttle. In the course of the second stage, a fundamentally new orbital station will be created, while the third stage will concentrate on the completion of the project in general.

The project provides for a variety of programmes of manned space flights and, in addition to Russian cosmonauts and American astronauts, crew members will be drawn from other countries of the existing space station partnership.

On November 7, 1993, the heads of the space agencies involved in the original International Space Station programme, i.e. the Canadian Space Agency (CSA), the European Space Agency (ESA), the National Space Development Agency of Japan (NASDA) and the United States National Aeronautics and Space Administration (NASA), together with the head of the Russian Space Agency (RSA), met in Montreal, Canada. This was the first collective meeting of the Space Station partners with Russia. The meeting reviewed the outcome of the joint NASA/RSA studies conducted over previous months and discussed the possible participation of Russia as a partner.

It was recognised that the project would be the largest such undertaking in history, bringing together the combined space efforts of Canada, Europe, Japan, Russia and the United States. CSA, ESA and NASDA had before them the 'Addendum to the Space Station Alpha Programme Implementation Plan' of November 1, 1993 on which date NASA had delivered its recommendation for Russian Involvement to the White House.

The heads of agencies noted that Phase 1 involving the Space Shuttle and the Mir station, with its attendant science, technology and operations activities, offered an early opportunity for learning and experience. This Phase was intended to greatly reduce the risk for all partners during the combined Phase 2/Phase 3 activities on constructing, operating and utilising the International Space Station.

On December 7, 1993 the United States, Canada, Japan and member states of the European Space Agency formally invited Russia to join the project. The partners recognised that Russia could make considerable contributions to the programme based on its "impressive record" of space accomplishments, including extensive experience in manned space flight.

The agreement on Russian participation does not override the existing US plan for developing the Alpha space station but calls for attaching a planned second-generation version of the Russian Mir station, called the Mir core module, to Alpha's basic support beam or truss. Attached modules would be built by the United States, Europe and Japan.

The Russians, as part of their participation, would equip Alpha with a crew rescue and return vehicle and possibly a "space tug" to provide the station with propulsion, guidance and attitude control.

The plan calls for the new station to be assembled in the orbit currently used by Mir, which is also much higher than that planned for Alpha. Construction of the joint facility would require 19 US Shuttle launches and 12 launches of Russian booster rockets. Present plans are for the station to be available for limited research in late 1997 and completed for permanent occupancy in October 2001.

On December 16, 1993, NASA and the RSA agreed to have up to 10 Shuttle flights to Mir with a total of 24 months time onboard Mir for US astronauts. A programme of scientific and technological research would be carried out and Mir's lifetime would be extended during the period 1995-97.

The following is a summary of cooperative activities outlined in the protocol signed by NASA Administrator Daniel S. Goldin and RSA Director General Yuri Koptev:

- An additional Russian cosmonaut will fly on Space Shuttle mission STS-63 scheduled for launch in 1995. Colonel Vladimir G. Titov, the back-up cosmonaut for the February 1994 flight (STS-60), will be the primary cosmonaut for the STS-63 flight. Sergei K. Krikalev, who is the STS-60 primary cosmonaut, will act as the back-up. During the STS-63 mission, the Space Shuttle will perform a rendezvous with the Mir-1 Space Station and will approach to a safe distance.
- The Space Shuttle will rendezvous and dock with the Mir-1 in October-November 1995 and the Shuttle crew may include Russian cosmonauts. Mir-1 equipment, including power supply and life support system elements will also be carried. The crew will return on the same Space Shuttle mission. This mission will include activities on Mir-1 and possible EVAs to upgrade the solar arrays.
- NASA-designated astronauts will fly on the Mir-1 space station for an additional 21 months. This will include at least four astronaut flights.
- The Space Shuttle will dock with Mir-1 up to ten times. The Shuttle flights will be used for crew exchange, technological experiments, logistics and sample return. Some of these flights will be dedicated to resources and equipment necessary for extending the life of Mir-1.
- A specific programme of technological and scientific research, including the utilisation of the Mir-1 Spektr and Priroda modules equipped with US experiments, will be developed by the Mission Science Joint Working Group.
- NASA and RSA will initiate the joint development of a solar dynamic power system with a test flight on the Space Shuttle and Mir in 1996. The joint development of spacecraft environmental control and life support systems will be undertaken as will studies on the development of a common space suit starting with the compatibility of their respective spacesuits.
- A crew medical support programme for the benefit of crewmembers of both sides will be initiated. ■

Space Station

Congressional Hearing

We note with interest that one of the Society's long-standing Fellows, Nicholas L. Johnson of the Kaman Sciences Corporation, Colorado Springs, Colorado, appeared before a Subcommittee of the US House of Representatives on 6 October 1993 to present a statement on the subject of Russian participation in the international space station programme.

Nick writes to ***Spaceflight*** about his work which summarised a top-level analysis of proposed space station designs, noting specific issues related to Russian participation in the US-led international space station programme. The work took a close look at the two principal designs submitted by NASA to the White House in September 1993, these being the Space Station Alpha design (***Spaceflight***, October 1993, p.353) and the US-International Partner - Russian (US-IP-R) space station concept, which was subsequently favoured in the announcement of 1 November.

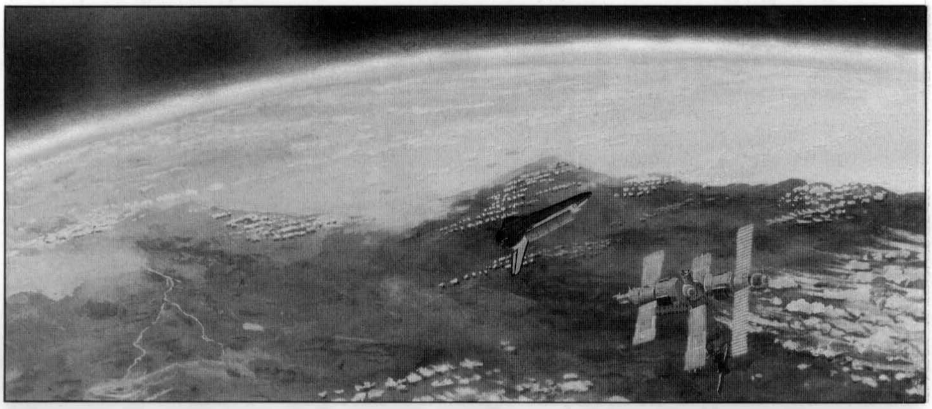
In his statement he said that the two proposed designs had to be addressed separately and that a full technical assessment and cost estimate of either could not be completed with sufficient confidence at this time due to a lack of engineering detail, and, in particular, to the absence of an operations programme after Permanent Human Capability (PHC) had been achieved.

Space Station Alpha

Space Station Alpha was considered to incorporate a rather limited role for Russian participation, a role essentially equated to that of a subcontractor in that two Assured Crew Return Vehicles (ACRV's) derived from the current Soyuz TM spacecraft would be provided with an option to employ two Salyut space tugs to furnish guidance, navigation and control (GNC) for the entire complex.

The US-IP-R Concept

On the other hand, the US-IP-R space station concept involved additional modules not found on Space Station Alpha, an integration of environmental control and life support (ECLS) systems, and a much greater reliance on both Russian hardware (some not yet developed) and launch services. For example, US Space Shuttle missions may be reduced by one-third as compared with the Space Station Alpha design if Russia were to assume responsibility for as many as 11 flights prior to PHC. This sharing of the launch requirements is made possible by a substantial increase in orbital inclination from 28.8 degrees to 51.6 degrees. While this alteration maximises Russian launch capabilities, all US Space Shuttle missions would suffer a marked reduction in payload capacity which for large cargo items must be offset by improvements to the Space Transportation System (STS) or the redesign of modules. At a minimum, more US or Russian missions will be required during the operational phase of the space station to deliver the same payload as that needed for support of a complex like Space Station Alpha.



Rendezvous at last. A US shuttle prepares for docking with the Russian Mir space station. The scene is set over Arizona, looking southwest, with the west coast, Los Angeles, and Baja California in the background. **Painting by WILLIAM K. HARTMANN**

In comparison with Space Station Alpha, the definition of the US-IP-R space station is much less mature, and, hence, the identification of potential design and operational deficiencies is hampered. However, some issues relating to Russian participation, which were not applicable or were of marginal importance to the Space Station Alpha, may have a marked technical or economic impact on the space station programme which can only be ascertained with more thorough concept definition and analysis.

Baikonur

The future of the Baikonur Cosmodrome, which has conducted space missions at a steady rate of more than 20 flights annually over the last three years, was also referred to in the statement. Since Baikonur would play a vital role in the deployment and presumably in the operation of the US-IP-R space station, the viability of that facility could be enhanced with the explicit inclusion of Kazakhstan as a state member of the space station programme.

Conclusion

The cost of Russian participation in the space station programme must include US integration expenses which can amount to a substantial fraction of or even exceed the hardware acquisition price. Examples of the extent of these supplementary costs, which arise from both technical and bureaucratic requirements, can be found even in much smaller cooperative programmes such as Topaz and the future STS-Mir mission.

In closing his statement, Nick reiterated that the notional architectures currently before the Subcommittee represented only a first step and were inadequately defined, in terms of both the deployment and operational phases of the space station programme, to permit technical and budgetary assessments with requisite confidence. "However, no insurmountable problems have yet arisen", he said, adding "I believe that the existing deficiencies can be remedied with due diligence to permit a responsible selection of the design options". ■

Russian Seven-Year Plan

The Russian Government plans to fundamentally reform the country's space industry. On December 11, 1993, the Russian Prime Minister Viktor Chernomyrdin signed a decree "On State Support for the Russian Federation Space Industry" which includes approval of a Russian Space programme up to year 2000.

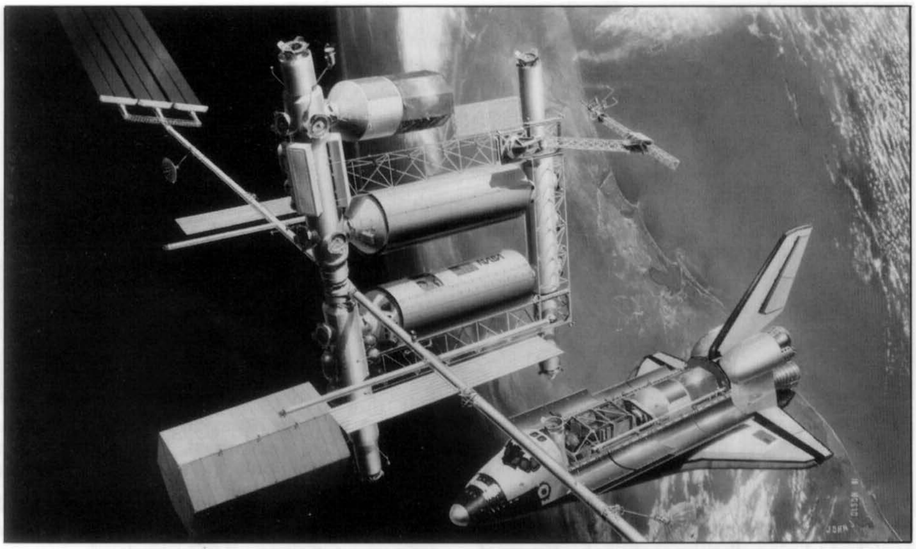
In the sphere of manned flights the Russians undertake to use the Mir station up to 1997 and in 1994 to launch two research modules to it. After the station's resources are exhausted manned flights will be executed within the framework of the new international station.

As a consequence of the decree the number of Russian space enterprises is to be reduced threefold, and those remaining will be independent of their CIS "colleagues" in the very near future.

The 17-point decree is mainly concerned with reorganisation and new administrative and contractural procedures. In the first part of it the state promises to repay all debts for current R&D's, purchase of mass-produced equipment and for operating expenses on the Baikonur spacedrome.

The second part stipulates a sharp reduction of space industry enterprises. About 40 federal space centres will be created that will act as state contractors for space equipment production. The decree provides for work to be done by Russian enterprises on items formerly produced at CIS enterprises. For 36 years, the development of Soviet astronautics was marked by isolationism. Now financial difficulties have forced the Russian authorities to find ways to attract foreign investment. In this context, cool "space" relations between CIS countries appear quite logical. The concentration of production in Russia creates additional guarantees for the latter to meet its international commitments and is a prerequisite to creating additional jobs.

RIA-NOVOSTI



For the US, a space station project has been long in the making. In this illustration of 1981, the Space Shuttle was already seen as fulfilling a key role. NASA/JSC: JOHN J. OLSON

Space Station Reconceptualised:

An Apollo-Soyuz Project for the 1990's

BY JOAN JOHNSON-FREESE
and
GEORGE M. MOORE
Air University, Air War College,
Maxwell AFB, Alabama

"We can follow our dreams to distant stars, living and working in space for peaceful economic and scientific gain. Tonight, I am directing NASA to develop a permanently manned Space Station and to do it within a decade."
President Ronald Reagan, State of the Union Address, 5 January 1984.

In June 1993, the Clinton Administration announced its support for a scaled-down version of the Space Station Freedom project which had been bantered (or battered) about since President Reagan's announcement in 1984. That scaled-down design, one of a series of downsizings from the original version, is referred to as Space Station Alpha by the National Aeronautics and Space Administration (NASA). US and Russian officials then agreed in September 1993 to begin merging their human spaceflight efforts, focusing on incorporation of Russian components into the once-again-to-be-reconfigured space station design.

Although many details and final agreements remain to be worked out, the configuration is to draw heavily from both Alpha and Mir 2, while maintaining the options of the original Freedom international partners. NASA Administrator Daniel Goldin has been quoted as promising this as the final redesign. It is difficult for some sceptics not to consider this proclamation as similar to that of the boy who cried wolf once too often.

Since announcement of Russian inclusion as a partner in the project, the newest and most radically redesigned variation-on-a-theme station has been popularly referred to as everything from the Russian Alpha, to Ralpha, to simply the international space station. In an astute bit of politics, by including the Russians in the venture, the Clinton Administration has provided the station with a new *raison d'être*, one of a familiar nature to members of the US Congress seasoned and unseasoned: it will be a symbol of the end of the Cold War and of a new era of cooperation. A new space station will certainly face further trials and tribulations in the US Congress with the $2.1 billion annual 1993/94 spending cap set by President Clinton in June 1993 for the station and because significant US aerospace jobs will likely be jeopardized as a result of the June downsizing. Whether it will survive is a question likely to be ultimately answered according to decisions and announcements made in the near future concerning space station rationale and utility.

Cooperation works only when goals are realistic, clearly stated and agreed by all

The initial announcements of this seventh redesign in nine years did not provide a detailed list of the space station's scientific goals and the required compromises which will merge the manned space flight programs of Russia and the United States with the engineering and technical research programs of the Canadian, European and Japanese Space Agencies. Soon, concerns must be addressed regarding power available on the station and the effect a continuously manned platform might have on materials and other research requiring a stable microgravity environment which is relatively vibration free. Clearly stated operational and scientific goals which support each of the space station participants' programs will help to solidify vacillating support, not only in the US Congress but among the foreign governments involved. Without a plan which contains clearly stated goals there can be no definition for the success of the space station, which increases chances of perceived failure in the eyes of participants and critics alike.

The Politics of Big Science/High-Tech Projects

Multi-billion dollar projects require high-level backing from their inception, and equally important, they require a full follow-through effort to garner public and Congressional support for the long-haul. President John F. Kennedy committed the United States to safely sending and returning an American to the Moon before the end of the decade of the 1960's not because he saw it as a scientific imperative, or because he believed in space as the next American frontier, but because of the political benefits he saw as subsequently accruing to the United States toward winning the Cold War. He therefore committed the United States politically and financially, through instructions to the executive budget office, to achieving his stated goal and made sure through Vice-President Lyndon Johnson that the requisite support in Congress was attained. President Reagan did much the same with his Strategic Defense Initiative (SDI); making the promise and then following through with executive directives to the appropriate budget officials to make it happen, and actively lobbying Congress for support of the project. The space station, however, enjoyed little of the same kind of financial backing from the White House as did either Apollo or SDI, even from the beginning.

The space station entered the arena of high-tech, high-ticket projects competing for Congressional funding with the advantage of having a symbolic national interest cloak, but not with

active, whole-hearted White House follow-on protection and promotion. So NASA (with help from everyone in Washington from Congressional staffers to OMB personnel) designed a "something for everybody" station, a general purpose facility which as usual meant that nobody could clearly identify its utility. Almost immediately following President Reagan's announcement of the program, the Congressional Office of Technology Assessment challenged whether there was a justifiable reason for a station facility like the one loosely envisioned by NASA. Their primary concern, again, was that it was too generally defined.

The pricetag had to be "reasonable" when compared to other high-tech projects; not as high as the SDI program, initially estimated to require $25 billion in R&D alone to establish the mere feasibility of such a system, but within the range of such science programs as the Super Conducting Super Collider (SCC), with its estimated $10 billion pricetag, or the Air Force's B-2 bomber at eventually $2.2 billion per plane. The $8 billion set for the dual-keel design was clearly seen as high for a science project, but politically it was more saleable than the SCC, for example, because of its symbolic connotations. The fact that the cost was underestimated for successful completion of the project became obvious soon after its approval.

Apollo: A Show of Leadership in an Era of Competition

The Apollo programme was initiated and carried out under quasi war-like conditions, where no amount of money was too much to carry the effort to success, until the fiscal year (FY) 1964 budget. Beginning in the mid-1960's, however, the need for money to support the Viet Nam war effort and then the Nixon programme of détente which replaced the "hot" Cold War, public and governmental interest and subsequently funding for the Apollo programme faded. After the first Moon landing, which unequivocally demonstrated US technical supremacy, the programme took on the connotation as an interesting science programme rather than a security-related effort. Three lunar landings were cancelled as American attention was drawn elsewhere.

The last Saturn launch vehicle was used for the Apollo-Soyuz Test Project (ASTP) in 1975, a highly visible symbol of US-Soviet détente. That project, referred to by critics as a "wheat deal in the sky" and a "quarter-billion dollar space handshake," has been the most visible, and for many people the most memorable, example of international cooperation in space to date. Hardware developed as part of a programme initiated in a competitive, "space race" mode, was eventually used as a shining symbol of cooperative international geopolitical relations.

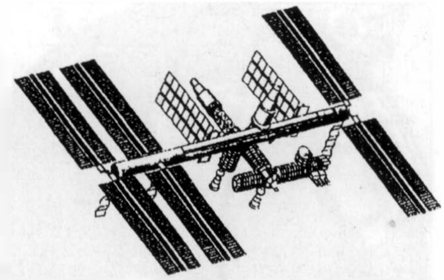
One of the key lessons learned from ASTP was that international cooperative science programs should be designed and approved on their scientific merits and their success evaluated on the same basis. A State Department official testifying before Congress in 1984 stated that "...cooperative projects in space have not had any direct influence on Soviet geopolitical and military aims. For example, the Apollo-Soyuz project did nothing to restrain the Soviet Union's adventurism in Angola or the invasion of Afghanistan..." [1]. Expectations for substantive change in international relations based on cooperative scientific endeavours are totally unrealistic and set such projects up to be labelled as failures. Cooperation works only when goals are realistic, clearly stated and agreed upon by all.

. . . the Apollo-Soyuz Test Project (ASTP) in 1975 . . . has been the most visible, and for many people the most memorable, example of international cooperation in space to date

Apollo Revisited: The Space Station

To evaluate the chances of success of the yet-again reconfigured space station, it is first necessary to examine the political environment within which Freedom was originally conceived and how the situation has changed since that time. NASA, particularly Administrator James Beggs, began quietly but vigorously pushing for a space station as a "logical next step" in the early 1980's. Few outside of NASA, however, jumped on the bandwagon. Beyond the Department of Defense's clear disinterest and the Office of Management and Budget shunning of the project because of the pricetag, a 1983 report from the National Academy of Sciences' Space Science Board was particularly damming in seeing no need for a space station as envisioned. Then how did NASA get the nod? It was sold to President Reagan personally as a step toward the commercial development of space and a show of US leadership. Both of these rationale fit well with the Reagan philosophy and worldview for the United States.

In March 1983, President Reagan announced his Strategic Defense Initiative, or Star Wars program. This was still a time of extremely negative rhetoric about the Soviet Union from the Reagan Administration. Indeed, it was also in a March 1983 speech to



Christian Fundamentalists in Orlando, Florida that President Reagan referred to the Soviet Union as the "focus of evil in the modern world...an evil empire." The environment and mood, therefore, was one not of cooperation with the Soviets but competition; one where a united Western front, showing its technological strength through a spectacular programme such as the initial dual-keel space station design involved, was expected to go far in showing US leadership politically and technologically.

The evolution of the Space Station Freedom programme is in many ways analogous with that of the Apollo program. Being also initiated in a era of competition with the Soviets, space station success could then be viewed as part of the overall national security concerns of the United States. With Japan, Canada and Europe as partners, the West was showing solidarity and technical expertise (particularly since the Soviets/Russians have had orbiting stations for 22 years) in a field always symbolic of the highest risks, the utmost in challenges, and the greatest potential for returns - although the real potential was and is still largely unclear beyond symbolism. This effort was initiated at a time of Soviet belligerence in Afghanistan and a general Soviet military build-up which Reagan characterized as leaving the United States "second to one."

So although Freedom was initially envisioned and designed as a wholly civilian space project (a condition essential for the participation of some of the partners), it did have underlying symbolic aspects of being a part of the geopolitical struggle between East and West. In that context, the $8 billion pricetag estimated in 1984 was not unreasonable. Indeed, when compared to billion dollar airplanes being built as part of the Cold War effort, it was quite reasonable. President Reagan clearly wanted the space station to happen, but not at the expense of taking any money from SDI, much less at the cost of transferring or eroding support from that project.

Further, NASA's mishandling of the station programme specifically, and its own internal affairs generally, made short work in Congress of Reagan's accompanying 1984 promise of a 1% real rise in the NASA budget over the following 5 years. Promises such as that are usually reserved for

The Apollo-Soyuz Test Project (ASTP) of July 1975 remains to this day a unique example of joint international space activity. ASTP involved the standardisation of docking techniques between two very differently conceived spacecraft - the Apollo command-service module and a Soyuz spacecraft. The photograph shows the US Commander Tom Stafford and the Soviet commander Alexei Leonov during the 43 hours of joint activity. NASA

the Pentagon, thus showing Reagan's enthusiasm for the idea of a space station. That NASA could not manage to move the programme forward beyond the blueprint stage, even with the promise, illustrates how quickly things went downhill.

Unfortunately for space station proponents, the cost estimates began to rise at the same time that relations with the Soviets began to improve. The Evil Empire references from the Reagan Administration were replaced by invitations to Mikhail Gorbachev to discuss *glasnost*. The need for a high-tech Western project to symbolically show Western solidarity and technical leadership was, as during Apollo, gone. Space Station Freedom became just another high-ticket science project, one among many vying for a very limited amount of available dollars from a Congress pressed by short-term constituent demands. Support declined as estimated costs increased with Congressional criticism heaped on NASA for being responsible for such costs and unresponsive to Congressional direction to define and control all aspects of their budget. The station was faced with redesign after redesign intended to cut costs while maintaining a modicum of scientific integrity.

A key indicator of the real impact of these funding cuts is electric power to be available on the station to users above the required life support and command and control functions. Demanding, edge-of-technology scientific endeavours, such as exotic materials research and the associated power-gulping high temperature furnaces or the centrifuges used in life sciences research, are heavily dependent on sufficient and reliable electrical power. NASA is dependent on off-the-shelf solar array technology. There is no additional money available to examine solar thermal or other emerging technology in space-based electrical power systems, and space-based nuclear power development/use is politically unacceptable in the US. The result is a far less than optimum and complicated time-sharing programme for the scientific efforts. The original international partners assume that they will likely absorb most of the impact of this situation.

By the time of the Bush Administration, station proponents were facing an annual battle-of-the-budget with Congress over whether to continue or cut space station funding. Advocates admitted that aerospace jobs in key states such as California and Florida were the prime selling feature. Respecting international commitments was also a factor in favour of station support but, for the most part, Space Station Freedom had become a large public works programme. Few supporters even bothered to try and argue station scientific capabilities or technology development as reasons for continuing the programme. In 1989, Representative Robert Torricelli was quoted as saying to NASA officials that by trimming the station's capabilities "you are [turning] what presented itself as possibly the world's most advanced scientific laboratory into a giant orbiting recreational vehicle." [2]. Although his estimation of the station's potential under the best of scenarios may have been optimistic, his point was well taken.

An International Space Station?

Perhaps most frustrating and irritating for the international partners has been their exclusion from or at least minimal inclusion in critical decision-making. When NASA made major station design changes without consultation with the international partners, as was the case in 1989 with the so-called Langley redesign, an international outcry ensued. The immediate outcome was a reaffirmation of international participation and its importance and, by extension, the necessity for real substantive consultations. NASA seemed to get better at treating the partners as partners, rather than subcontractors.

But the 1993 addition of Russia as a participant caught most of the international partners by surprise, again putting their status as real "partners" in question. The possibility of losing, for political or economic reasons, one of the original partners at this point would certainly tarnish this shining symbol of international cooperation.

Representatives of the Japanese, Canadian and European Space Agencies have tentatively accepted Russia as an additional partner but also have expressed concern and reserve regarding the cost implications of further design modification and the delays which are implicit with it. In addition, they have expressed apprehension regarding how Russian participation will impact agreements defining station rights and responsibilities. Although the conceptual notion of bringing in the Russians is welcomed, and was even encouraged by some countries, the process by which it was done and the realities of the follow-through have been unsettling at best.

There are other considerations as well. It is important to remember that the original partners in Freedom were not motivated by the same concerns and leadership goals as those of the United States. NASA and President Reagan personally "sold" the Space Station as a permanently tended manned laboratory, with capabilities in a variety of science fields, perhaps most importantly that of materials science. "Future commercial return" was the condition on which the German government decided to participate in the programme. They saw station R&D as directly leading, in the long-term, to commercially viable products. The Japanese joined the space station effort for the officially stated reason of conducting materials research. They have annually held a space station utilization conference, only to find it nearly impossible to respond to researchers who now wonder just what it is they will be able to do on the space station because of the power cutbacks, limited space and limited laboratory access. Russian participation, even if station capabilities increase and more assurance of access is gained, creates as many new questions for the original partners as existing problems that it alleviates.

The Clinton Strategy

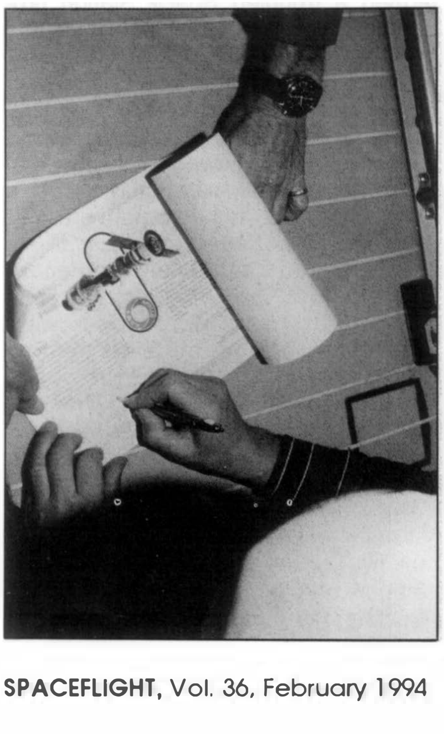
Enter the Clinton Administration. Candidate Clinton had promised to support the space station but President Clinton was faced with a bleaker economic picture than he had expected, and the necessity to find funding for his priority national health care programme. Yet another redesign was ordered in the Spring of 1992 when, admirably, everything was to be put on the table for reconsideration. Indeed, everything was considered, including participation by the Russians. The primary problem to be considered politically, however, was that yet another scaling back of the station, and consequently jobs for Americans, would jeopardize the fragile Congressional coalition that was holding this high-visibility, high-ticket science

project together.

Through a shrewd bit of political manoeuvring, the Clinton Administration is attempting to kill several birds with one stone in handling the problems inundating the space station. First, it redefined the station from the science project left to the Bush Administration by the Reagan Administration. That project may have pleased some life scientists and materials scientists but it was one from which the general public no longer saw any particular benefit or need. By including the Russians, Clinton has again transformed it to a project symbolic of the current state of international geopolitical affairs, this time a cooperative environment; in effect an Apollo-Soyuz project for the 1990's. In defining the station in geopolitical terms, the intent is clearly to seek Congressional support with arguments more ubiquitous than jobs. The Administration has also pledged that no US aerospace jobs will be lost as a result of Russian participation; the same is not necessarily true because of the general downsizing. Maintaining the international agreements already signed can also be pressed as an argument for Congressional support, especially because tying the Russians in with the US programme will, in effect, limit the options that otherwise might have been available to the other partners had they grown tired of US redesigns and procrastination.

As to whether there is actually a new mission defined for the station, or whether it is really any more of an "international" programme, as opposed to a US dominated programme with international participants, is dubious. Talk so far has been so focused on hardware and politics that "needs and uses" have remained vague. The good news for the original partners is that momentum seems to be building up for the project within the United States again, bolstering chances that the project may actually get off the ground, literally, before the end of the century.

An historic moment during the rendezvous day of the Apollo-Soyuz Test Project. The hands of cosmonaut Valery N. Kubasov are seen as the ASTP engineer adds his signature to the Soviet side of the official joint certificate marking this event. The left hand of astronaut Donald K. Slayton, NASA's docking module pilot is also in the picture. NASA



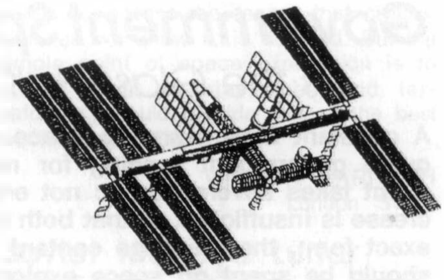
Conclusions

To its credit the Clinton Administration redefined, or reconceptualized, the space station far beyond what some observers thought they would do. It is generally accepted by space programme advocates that space is not a priority for this administration, so there was concern that the space station would be allowed to simply fade away in a fog of unreconciled proposals from executive budgeteers, Congressional staffers and NASA labs. At best, a "put all the cards on the table and with the international partners decide where to go" strategy was certainly desired. But, politics being the art of the possible, a half-way "let's reconceptualize the station to once again take on a geo-political spirit, and include the Russians" is perhaps the best that could realistically be hoped for.

If all goes as planned (or hoped) the "new" International Space Station will be the "next logical step" into space, as NASA has contended for many years

There is acute concern about the state of Russian politics and Russian ability to actually carry through commitments. That the Russian Parliament was under siege even as NASA officials were in Moscow to meet with Russian Space Agency officials in October 1993 was a source of great, and understandable, concern to US lawmakers. Whether a separate agreement need be signed with Kazakhstan, where a primary Russian launch site is located, is another of many issues overshadowing the clear desire of both US and Russian officials to work out an agreement acceptable to all. Further, there is a question as to when the final negotiations will reach the appropriate Former Soviet Union heads of state who actually have the authority to commit resources.

The current weaknesses and inconsistencies in the world economy certainly have the potential to impact all participants adversely as they prioritize support for the space station among all other economic concerns. It may well become the case, for example, that one participant may desire



to supply services or logistic support for the station in lieu of monetary payment for part of their share of construction and/or operational costs. This would certainly impact the US funding profile in that the US is planning to provide a significant portion of the support services for the station, to be paid for by the other partners. In view of the current mood in Congress, this is one of the most glaring in the long list of unresolved issues facing the station partnership. If international cooperation is the *raison d'être* for the new station, leaving such issues unresolved opens the door for international discontent.

If all goes as planned (or hoped) the "new" international space station will be the "next logical step" into space, as NASA has contended for many years. What it will actually accomplish remains to be seen. For the US, a clear statement of goals and missions for the station must be the interim "logical next step" and is essential to station survival of Congressional scrutiny once euphoria over a programme symbolic of our new spirit of cooperation with the Russians wanes. A bipartisan group of US lawmakers, including Representative George Brown, who chairs the House Science, Space and Technology Committee; and Representative Louis Stokes have been quoted as saying, "Unless a more acceptable plan for proceeding with the space station is provided for congressional consideration, it is doubtful that it will be approved or have our support next year." [3]. Clearly representatives Brown and Stokes, *et al*, not only understand international geopolitics, but US politics as well. Hopefully, the Clinton Administration will do as well in recognizing and taking the necessary steps to avoid the pitfalls that the station may encounter without a detailed mission statement and a realistic programme budget, unambiguously set forth, agreed to by all, and strictly followed.

References

1. East-West Cooperation in Outer Space, hearings before the Senate Committee on Foreign Relations, 13 September 1984 (Washington DC: US GPO, 1984) 71.
2. "Space Station's Science Up in the Air", *Science*, 1 December 1989, 1110.
3. Andrew Lawler, "House Quartet Challenges New Station Plan", *Space News*, November 29 - December 5, 1.

Government Spending on Space

Is the Glass Half Full or Half Empty?

A constant lament among space enthusiasts concerns the lack of adequate government funding for national space programmes. The complaint takes several forms: not enough is being spent or the rate of increase is insufficient or that both of the above are true. Regardless of the exact form, the message content is the same: more (often much more) should be spent on space exploration and exploitation activities. Grandiose and expensive initiatives are regularly proposed and seriously discussed but most disappear from sight without a trace. There is no money.

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The Political Environment

Such complaints reflect a lack of comprehension of the political environment within which most government budget decisions are made. In fact, one could argue conversely that given the political practicalities, space does disproportionately well in the competition for funding. One may want more but should not ignore what has been given.

The consideration that space policy receives from the political authorities depends on several factors. First, one must always remember that space funding is purely discretionary spending. All that means is that the government does not consider the spending legally or politically compulsory compared to items such as, for example, retirement benefits, health care or defense. Those items are normally considered mandatory, politically difficult if not practically impossible to severely reduce or eliminate, depending on the political forces aligned behind each programme.

Adverse programme decisions generate immediate and intense reactions (especially proposed social programme cuts), possibly threatening the government's continued political viability. Thus, controlling welfare expenditures has proved to be difficult for almost all governments. The constituencies are perceived as too powerful and well entrenched. By contrast, space expenditures are comparatively easy to cut as the affected constituency is comparatively small and unorganised. The space community is often loud enough to deter the weak of heart, but a determined government is not likely to be intimidated.

Second, politicians are leery of failure, especially, of expensive highly visible public failures. Such failures (fairly or not) are perceived as reflections on the government and are thus to be avoided. Valid reasons may explain each problem but, for the political class, the fundamental inescapable reality is that something went wrong.

Space is a difficult enterprise at best and is also a very expensive one. In addition, its failures are often dramatic and highly visible. The Mars Observer had the virtue of being out of sight. Television has proved to be a two-edged sword that is not controlled by the space agencies. The agencies want, even demand, media coverage but like a trapeze artist have nowhere to hide if the rocket fails. This lesson began with Vanguard and continues to the present.

Third and more positively, space as a field for human curiosity has proved to be extremely attractive despite its problems. Visiting planets and comets along with surveying the planet Earth from on high attracts one's interest regardless of the exact understanding of the science or the purpose of the mission. The science is often magic to the public including government leaders. Space retains the aura of the frontier along with the very distant prospect of economic largesse. The latter, except for a few very selected fields (most notably satellite-based telecommunications), has proved to be more difficult than expected and will not occur until launch costs among other things decline precipitously.

Space Funding

As a policy analyst and a political scientist by training, I find government support for space-related activities to be much stronger than a mere political calculus would predict as likely. Within the United States political process, for example, space budgets compete directly with several social programmes including veteran's benefits and public housing. Both of these programmes are supported by constituencies much larger and better organised politically than those found in the field of space. Despite this supposed disadvantage, funding for space has consistently done well in the unending quest for comparatively stable funding.

Space funding is not and cannot be immune from the general state of government spending for all its programmes. Space is not seen as essential for national survival. Space activities such as environmental monitoring may deal with critical world problems but such difficulties are perceived as long term in nature. One may vehemently disagree with how the decision makers' assess the comparative risks, but, until that assessment is substantially altered, little will happen to increase space budgets.

Measured against the expectations of the enthusiasts, the amount appropriated both in total and rate-of-change clearly is insufficient. The reality is that space has done well budgetarily speaking despite the persistent problems in defining its future. Given the fiscal constraints pinching most governments, merely asking for more money without a well defined set of objectives is unlikely to loosen purse strings. Projects by themselves do not constitute an agenda.

There is still strong support for space-related activities because of their scientific promise and performance despite recent disappointments such as the loss of Mars Observer. What has become especially problematic is automatic support for increased manned flight operations unless there is a well defined goal. The Space Station redesigns and Shuttle budgetary problems have tainted the earlier reservoir of support in the United States which must be rebuilt by conducting successful operations within present budget limits. No longer will money routinely flow to correct mistakes - the abrupt cancellation of the Superconducting Super Collider is stark evidence of that point. 'Unforeseen events occur but, when NASA programmes average 200 percent or more of original budget projections, the problem is more systemic than merely chance happenings. ESA confronts similar hard choices in stretching out programmes to handle an unexpectedly turbulent fiscal climate.

Space Commitment

The fundamental commitment to space can be seen in two ongoing events. First, President Clinton's willingness to support what can only be termed a troubled Space Station programme was not automatic given the budget fiascos and continual redesigns of the past few years. The second was the restructuring but general continuation of the ESA programme especially the renewed willingness of Germany to participate more fully. In both instances, ambitions were tailored down to more accurately fit resources and especially projected budgets, but the essential decision was to press on. These choices were particularly critical because returns from space still remain largely intangible and scientific in nature. Even so, there remains a residual positive feeling toward space which continues to render assistance when critical decisions have to be made.

When one eyes the glass carefully, the only logical conclusion is that it is half full and hopefully on the way to reaching the brim. ■

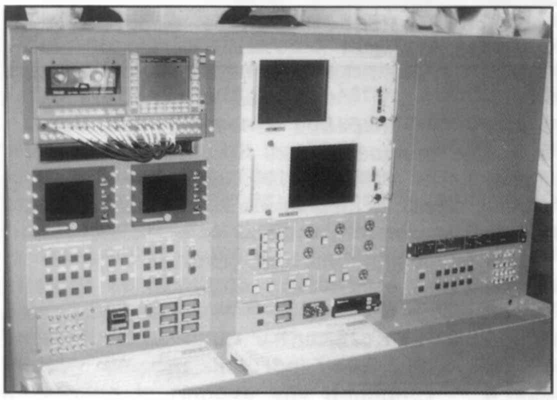
Pegasus Launch Aircraft

On December 6, 1993, Orbital Sciences Corporation's new L-1011 launch aircraft made a press call at Edwards AFB. Named "Stargazer," the aircraft is designed to carry the new Pegasus XL and XLS air-launched boosters.

View of the L-1011 launch aircraft on the ramp at the Dryden Flight Research Center. The aircraft was extensively modified to accommodate the Pegasus air-launched booster. The aircraft replaces the NASA NB-52 used for the first flights.

BY CURTIS PEEBLES
Fellow BIS

The aircraft, the 67th L-1011 built, was purchased from Air Canada and was delivered to Marshall Aerospace, Cambridge, England for some 18 months of modifications. It made its first test flight on July 12, 1993 and on its sixth flight, on August 10 1993, it carried a dummy Pegasus XL for the first time. In all, 22 test flights were made. Ground tests were also made



The launch control panel aboard the L-1011. The two CRTs on the left are for the television cameras, while the two in the centre are for telemetry. On the lower right is the payload control panel. The two keyboards are identical to those of an AT-class personal computer. Human factors and input from the launch officers went into the design of a very compact unit.

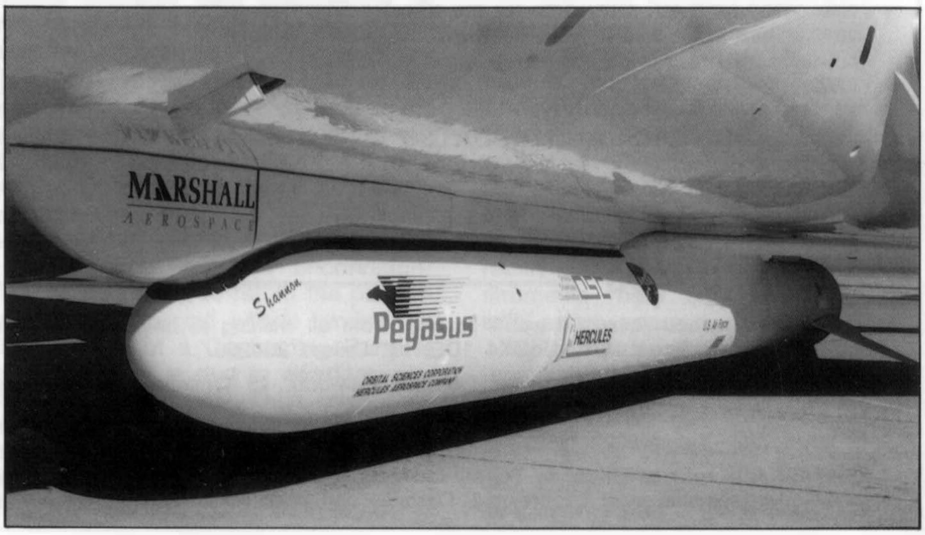
of the release mechanism, the dummy Pegasus XL being dropped on to its transporter. Even this caused the L-1011's nose gear to bob up and down. The L-1011 was formally delivered on November 21, 1993. It was then flown across the Atlantic, stopping at Washington's Dulles International Airport, Huntsville's Redstone Army Airfield, Phoenix's Sky Harbor Airport, and the Dryden Flight Research Center at Edwards AFB. Its final home base is Meadows Field Airport in Bakersfield, California.

The transformation of a 1970s wide-body airliner into a 21st century satellite launcher proved quite extensive. The main passenger cabin has been stripped of its seats and panelling. The under-floor galley was also removed and converted to hold 10 nitrogen bottles, air conditioning, and hydraulic system. These are used to support the Pegasus and the payload before launch.

The major change is the addition of the release mechanism. The Pegasus is held by five hooks - four on the launch cradle and one on the forward section of the Pegasus. The latter insures the Pegasus fuselage will not flex in flight. A hole was cut in the aft fuselage for the Pegasus' vertical tail. A fairing was also added under the forward fuselage. The gap between the Pegasus and the fairing is sealed with heavy brushes. The opening for the tail is sealed with brushes and movable doors. This reduces in-flight vibration and noise. Two television cameras, one looking aft at the Pegasus' nose and another looking forward toward the fins, monitor the booster.

In the centre of the former first-class section is the launch panel and the two operators' seats. The panel is a compact arrangement with all the screens and controls at eye level. Two CRTs relay images from the cameras. The rear camera is most important, as it monitors the pre-launch checks of the control fins' movements. Two other CRTs provide read-outs of the payload and booster telemetry. The panel also has controls for main power distribution, Pegasus power, camera controls, fault lights, and nitrogen control. The payload panel is simplicity itself - two buttons marked "Aux A and B" and 10 numbered buttons. The two keyboards are standard AT-class personal computer keyboards; straight out of your local computer store. The whole launch system is PC based.

The launch operators check out the Pegasus and payload: they give clearance to launch. The actual launch is performed by the pilot for safety reasons. He has an arm and a launch button on the centre console. The four main hooks release first, followed 0.05 seconds later by the forward hook. This causes the Pegasus to drop in a nose-up attitude, insuring the fin



Close-up view of the Dummy Pagasus XL. The booster is significantly longer and heavier than the original Pegasus. Launch will be made at an altitude of 38,000 feet. First stage ignition of the Pegasus XL will occur five seconds after release. The stage will burn for 72 seconds, then separate. The second and third stages will coast for 18.3 seconds, then the second stage will ignite for a 72.7 second burn. The third stage would then separate and coast for seven minutes, before making a 65 second burn. The maximum payload of the Pegasus XL is 1,000 pounds.

The gap between the booster and the forward fairing is sealed by thick brushes. The fairing is designed to accommodate both the XL and the future XLS growth version. Clearance between the XL and the ground is minimal. The booster is monitored in flight by two television cameras on the underside of the plane. There is no inflight access to the booster.

clears the fuselage cut-out. When the Pegasus is released, the L-1011 will rise upwards due to the loss of weight. The pilot also has an emergency jettison button to drop the Pegasus.

The L-1011 was designed to accommodate growth versions of the Pegasus, the XL and XLS. The original Pegasus was approaching the maximum payload of the NASA NB-52 used for the first launches. The Pegasus XL, with stretched first and second stages, is 17.08 meters long and weighs almost 23.6 tons. (Compared to 15.25 meters and just over 19 tons for the original Pegasus.) This would have exceeded the maximum payload of the NB-52. The Pegasus' tail fins have been angled down to clear the retracting main landing gear. For this reason, the size of the fins cannot be increased in any future growth versions. Ground clearance is minimal - the L-1011 must be raised to allow the Pegasus' handling trailer to be moved into position.

The Pegasus XLS is the same size as the XL, except for an increase in wingspan of 1.2 meters to 7.93 meters. The gross weight, however, is increased to almost 38.6 tons. This 60% increase required a modified release system, which involved adding to the structure, rather than a whole new system. All the other modifications were made with the XLS in mind.

One possible growth potential for the L-1011 would be to equip it to operate independently of range support. Although it does not use a ground pad, the Pegasus still requires range support such as radar and missile destruct control. The launch range must be scheduled in advance. It may be cancelled and it always adds to costs. Launching far off the coast would also ease abort requirements by giving larger margins. Hence to be independent of costly ground ranges would reduce costs and make the Pegasus more commercially attractive.

The first launch from the L-1011 will be made in early 1994. The payload will be the Air Force STEP-1 satellite. This will also be the first launch of the Pegasus XL. ■

SATELLITE DIGEST-261

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Cosmos 2266	1993-070A	Nov 2.51	Plesetsk	Cosmos-B	825 ?	Nov 3.08	82.95	104.79	950	1,019	[1]
Cosmos 2267	1993-071A	Nov 5.35	Tyuratam	Soyuz	6,500 ?	Nov 6.21	70.39	89.95	240	304	[2]
						Nov 24.93	70.38	89.97	247	299	
Gorizont 29	1993-072A	Nov 18.58	Tyuratam	Proton-4	2,125 ?	Nov 18.37	1.48	1,399.59	35,039	35,100	[3]
						Nov 28.23	1.46	1,436.04	35,758	35,813	
Solidaridad 1	1993-073A	Nov 20.05	Kourou	Ariane 44LP	2,776	Nov 22.25	6.94	631.56	216	35,795	[4]
						Nov 26.93	0.14	1,400.05	34,397	35,759	
METEOSAT 6	1993-073B				704	Nov 21.17	6.94	631.03	219	35,766	[5]
						Nov 26.93	1.35	1,435.01	35,760	35,771	
DSCS-3B 4	1993-074A	Nov 28.99	ER	Atlas-2	1,040 ?	Nov 29.23	26.50	625.47	185	35,513	[6]

NOTES

1. *Parus* military navigation satellite, co-planar with Cosmos 2195.
2. Photoreconnaissance satellite, possibly similar to the failed Cosmos 2243 (1993-028A). Actual classification is uncertain.
3. FSU* satellite leased to U.S. company RIMSAT Corporation: stationed over 130 ºE.
4. Mexican communications satellite built by Hughes Space & Communications Co: to be operational over 109 ºE.
5. ESA meteorological satellite to be operated by EUMETSAT: to be operational over 0 ºE.
6. U.S. Department of Defense communications satellite, also called USA 97. Only data for the transfer orbit have been issued to the end of November: normally no Two-Line orbital data are issued for newly-launched DSCS payloads.

ADDITIONS AND UPDATES

1976-024A Cosmos 808 decayed from orbit Nov 20.

1981-113A Molniya-1 51 decayed from orbit Nov 2.

1983-058A EUTELSAT-1 F1 was boosted off-station over 25-26 ºE at the end of September: it was still drifting in November.

1983-075 Debris designated 1983-075G-W has now been catalogued from the Cosmos 1484 break-up.

1990-094A Gorizont 21 was boosted off-station over 90 ºE in mid-November.

1993-056A UFO 2 was boosted off-station over 186 ºE at the end of October: it was still drifting in mid-November.

1993-064A Progress-M 20 undocked from the Mir Complex Nov 21.11: after the de-orbit manoeuvre a recoverable Raduga capsule returned to Earth Nov 21.38 while the main spacecraft burned up in the atmosphere.

1993-069A Add a geosynchronous orbit for Gorizont 28: Nov 3.40, 1.45º, 1,436.11 minutes, 35,765 km, 35,809 km. The satellite is located over 90 ºE (note Gorizont 21 above).

* FSU = Former Soviet Union

Seven Ariane Launches in 1993

For the last launch of 1993, Arianespace successfully placed two satellites into orbit on December 17, 1993: DBS-1, the first American direct TV broadcast satellite and Thalcom 1, Thailand's first telecommunications satellite. In 1993, Arianespace placed 10 satellites in orbit with seven launches.

The launch vehicle for Flight 62 was an Ariane 44L, the most powerful version of the European launcher equipped with four liquid-propellant boosters. Life-off was from the Space Center in Kourou, French Guiana.

Provisional parameters at third stage injection into geostationary transfer orbit were:

Perigee: 198.0 km for a target of 199.6 (± 3) km
Apogee: 36.349 km for a target of 36,405 (± 156) km
Inclination: 3.97 degrees for a target of 4 (± 0.06) degrees

DBS-1, the first direct TV broadcast satellite for North America, was built by Hughes Space and Communications Inc. Weighing 2,860 kg at lift-off, it is equipped with sixteen 120 watt transponders optimised for digital transmission. The DBS-1 will be operated by two American satellite operators: DirecTv and United States Satellite Broadcasting (USSB).

Thaicom 1 is the first satellite launched for Thailand. Designed and built by Hughes Space and Communications for Shinawatra Satellite Co Ltd., it will permit the development of Thailand's telecommunications system. Weighing 1,080 kg at launch, it is a prime example of a satellite in the SDS class (Spelda Dedicated Satellite) enabling Arianespace to offer operators rapid access to space at a very competitive price.

The next Arianespace launch has been scheduled for January 20, 1994. An Ariane 44L vehicle will be used to place two satellites into geostationary orbit: Turksat 1, Turkey's first telecommunications satellite: and Eutelsat II F5, for the European Telecommunications Satellite Organisation. Following Flight 62, Arianespace's backlog now stands at 37 satellites to be launched, worth approximately £2 billion.

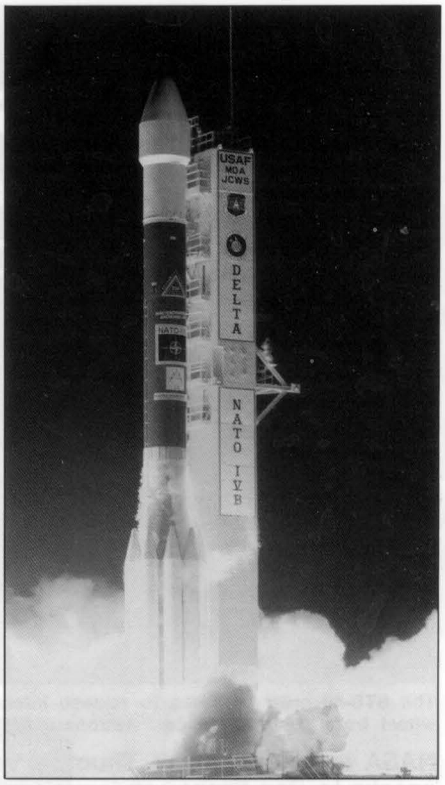
Rosetta Comet Mission

In November 1993, ESA selected Rosetta, a comet rendezvous mission, as the third cornerstone of its Horizon 2000 programme (*Spaceflight*, November 1993, p.375). Also selected was FIRST (the Far Infrared Space Telescope) as the fourth cornerstone mission. The launch dates will be 2003 and 2006 respectively. However, FIRST will return its scientific data earlier than Rosetta, as the travel time to the comet is rather long.

Rosetta was originally conceived as a comet-nucleus sample-return mission that would bring back cometary material to Earth for laboratory analysis. The original mission could not, however, be implemented as it was too ambitious and too complex. Therefore in 1992 the concept had to be revised. The mission was reconsidered as one to be performed by ESA alone on the basis of European technology and the Ariane 5 launch capability. However, the opportunity for other agencies to join and augment the scientific return was left open, and international partners have already indicated to ESA their interest to join.

The new baseline mission is a rendezvous with a comet and at least one (most probably two) flybys of asteroids. After gravity-assist manoeuvres at the Earth and Mars or Venus to acquire the necessary energy to reach the comet at aphelion (its farthest point from the Sun), the spacecraft will stay with the comet along its trajectory into the inner Solar System through perihelion (its nearest point to the Sun) to study the material that constitutes the comet and how the cometary processes evolve with decreasing distance from the Sun. A Surface Science Station will be deployed onto the comet's surface to provide in-situ studies of the nucleus.

The mission retains as far as possible the objectives of the original comet-nucleus sample-return mission and concentrates on the in-situ investigations of cometary matter and the structure of the nucleus. Potential target comets are Schwassmann-Wachmann 3, Wirtanen, Finlay and Brooks 2 for a launch in the time interval 2002-2004. The major elements of the Horizon 2000 science programme are now under way and ESA will start the process to define the 'post-Horizon 2000' programme.



46th consecutive successful launch of a Delta 2 rocket carrying a British NATO communications satellite at 7:48 pm EST Tuesday December 7, 1993 from Cape Canaveral Air Force Station. This is the longest successful launch record of any rocket.
PETER QUALTIERI, *THE WEST KENTUCKY NEWS*

Second NATO Satellite Launched

The launch pictured above carried the NATO IVB communications satellite into geosynchronous transfer orbit for NATO and the UK Ministry of Defence (MOD). It will provide communications for NATO member nations and military command and control for forces under NATO.

The NATO IV constellation is composed of two spacecraft intended to provide communications for the next decade. The project is managed by MOD on behalf of NACISA, the NATO Communications and Information Systems Agency, under a memorandum of understanding with the UK government. The first spacecraft, the NATO IVA built by British Aerospace Space Systems and Marconi Space Systems, was successfully launched by a Delta II rocket on January 7, 1991.

New China-Brazil Agreement

A previous China-Brazil agreement for the construction of two "China-Brazil Earth Resource Satellites" (CBERS) was signed in July 1988. Brazilian participation in the construction of CBERS corresponds to 30% of the whole programme, the Chinese Academy of Space Technology (CAST) being responsible for 70% of the programme. The total cost for the construction of the two satellites is initially estimated as US$150 million.

A contract for the launch of the two CBERS has now been signed in Beijing on November 9, 1993 between the Brazilian Ministry of Science and Technology and the Chinese Great Wall Co. The launch of the first CBERS satellite is scheduled for October 1996. It will be launched by a Chinese Long March rocket from the Shanxi launching base.

New Crew for Mir

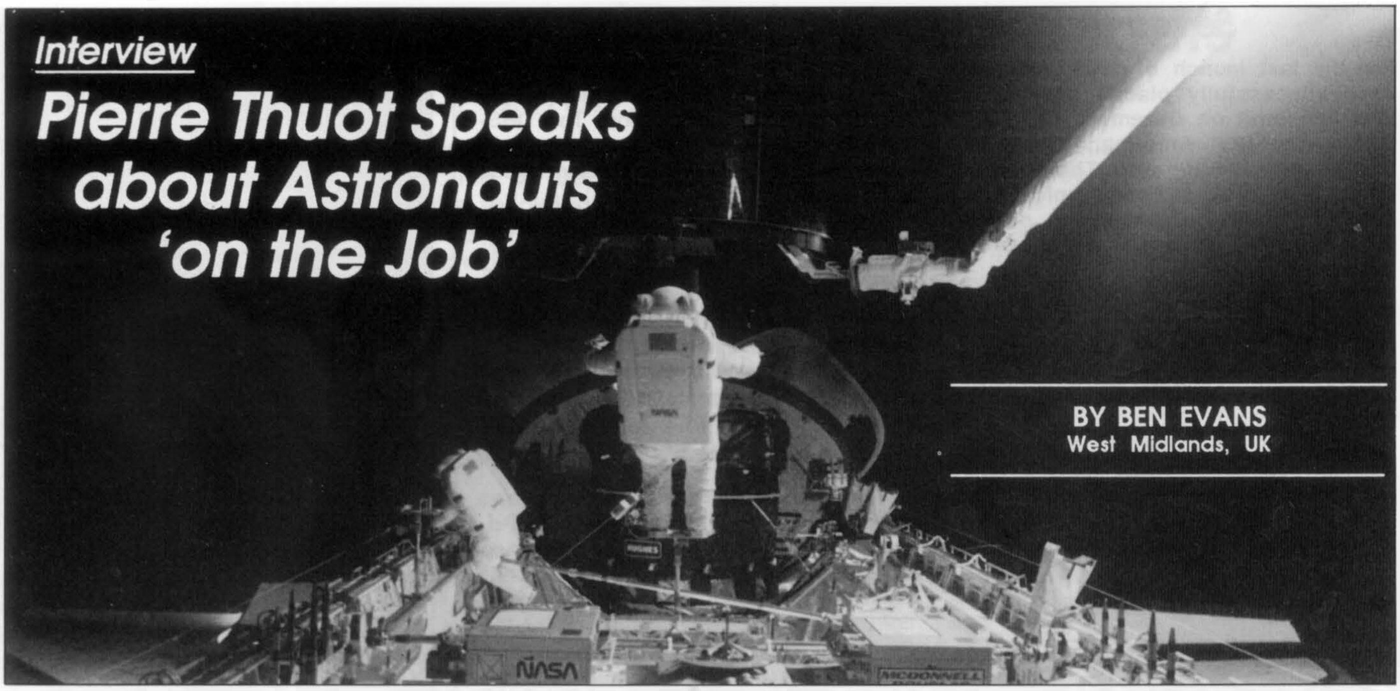
The Soyuz TM-18 spacecraft was launched on 8 January from Baikonur for a rendezvous in orbit with the Mir space station in a mission intended to break the world record for the longest stay in space. The launch had been delayed for two months because of a shortage of booster rockets.

Two members of the crew, commander Viktor Afansyev and engineer Yuri Usachev, will stay on the station until July 4. The third, 51-year-old physician Valery Polyakov, will try to stay for 427 days to break the record of 366 days set by cosmonauts Vladimir Titov and Musa Manarov in a missions that ended in December 1988. During the mission three unmanned supply ships will be sent to Mir, which will be repaired and maintained by the cosmonauts who will also conduct experiments.

Interview

Pierre Thuot Speaks about Astronauts 'on the Job'

BY BEN EVANS
West Midlands, UK



The STS-49 crew prepares to release Intelsat VI into space once more. Astronaut Thomas D. Akers awaits a cue to remove the steering wheel from the grapple bar. Astronaut Richard J. Hieb remains near the starboard longerons. NASA

NASA astronaut Pierre Thuot, a veteran of two Space Shuttle missions, speaks to *Ben Evans* concerning his second flight in May 1992 which successfully reboosted the Intelsat-VI commercial telecommunications satellite. This spectacular mission (STS-49) was also the maiden voyage of NASA's youngest Shuttle orbiter, Endeavour.

Pierre Thuot began by describing the post-mission activities of the seven STS-49 crew members during the first few weeks after the flight.

'For the first three weeks after the mission, our time was consumed with debriefings by all the various engineering and support folks who helped us with the successful capture of the satellite as well as the other mission objectives, and for the next month [June to July 1992] we were on-the-road pretty much doing public appearances and speaking about our mission to various groups all over the nation'.

My first question to Pierre Thuot concerned the confusing issue of Shuttle flight manifesting arrangements, specifically relating to the Intelsat mission.

He explained that originally the Intelsat reboost was assigned to Shuttle mission STS-50, with the STS-49 slot being occupied by a demonstration test-flight of the Flight Telerobotic Servicer. The FTS was subsequently postponed until STS-62 in early 1994, before being cancelled and wiped from the Shuttle manifest completely in mid 1992. This allowed the Intelsat reboost mission to be reallocated to STS-49's slot with the US Microgravity Laboratory (USML) Spacelab mission joining STS-50.

I enquired after the reasons by he and his fellow astronaut Rick Hieb had been unable to capture Intelsat during their first two attempts after eighteen months of intensive training.

He replied that the reason was due to 'a dynamics problem: the satellite was much more dynamic than our training had led us to believe and the capture bar was very difficult to apply in that situation'.

I then asked Pierre Thuot to comment on the requirement for further spacewalk experience prior to Space Station assembly, following the crew's discussions with reporters during their flight that the EVA training programme had been unrealistic and therefore unable to accurately simulate the space environment.

'I believe we need to increase our experience level', he replied, 'amongst the Astronaut Office as well as amongst the Johnson Space Center EVA team, since we've only had two missions with spacewalks since we resumed flying in 1988; I think it is very important that we should fly more missions to prepare us for the Space Station'. Generalising, he believed that NASA's training facilities were very good - the best in the world - saying that 'there's not too much I'd change about them'.

Interestingly, the comments from the STS-49 crew seemed to have some impact upon NASA's management because only a few months later the agency inaugurated the 'generic spacewalk' programme with the excursion of astronauts Greg Harbaugh and Mario Runco during the STS-54 mission.

My final question concerned secondary payloads aboard the mission in addition to the Intelsat-VI reboost hardware and the ASEM experiment.

He replied: 'We carried a commercial protein crystal growth experiment and this was really the only secondary payload flown; but we also carried a number of Detailed Supplementary Objectives, which were medical experiments, and we carried a bicycle ergometer which we were evaluating for the Space Station. Most of our activities involved the two main payloads in the payload bay, the ASEM and the Intelsat reboost hardware'.

Pierre Thuot then spoke about the STS-49 mission.

After the successful third excursion of the STS-49 mission - which featured Thuot, Hieb and Tom Akers in the first ever three person spacewalk - the intrepid astronauts reentered the payload bay yet again to 'clean up the bay after the deployment of Intelsat, and to stow foot restraints and cameras purposefully left in the payload bay prior to the deployment'.

He mentioned the fourth EVA on May 14, 1992, which primarily involved astronauts Akers and Kathy Thornton in the long awaited demonstration of the Assembly of Structures by EVA Methods (ASEM) experiment. 'What they were basically doing was evaluating new hardware and new concepts to help with the construction of the Space Station. During their EVA, I was the IV [intravehicular] crewman inside the cabin responsible for monitoring what they were doing and keeping

track of all the hardware that they had taken outside to ensure that it was all stowed properly before the end of the EVA'.

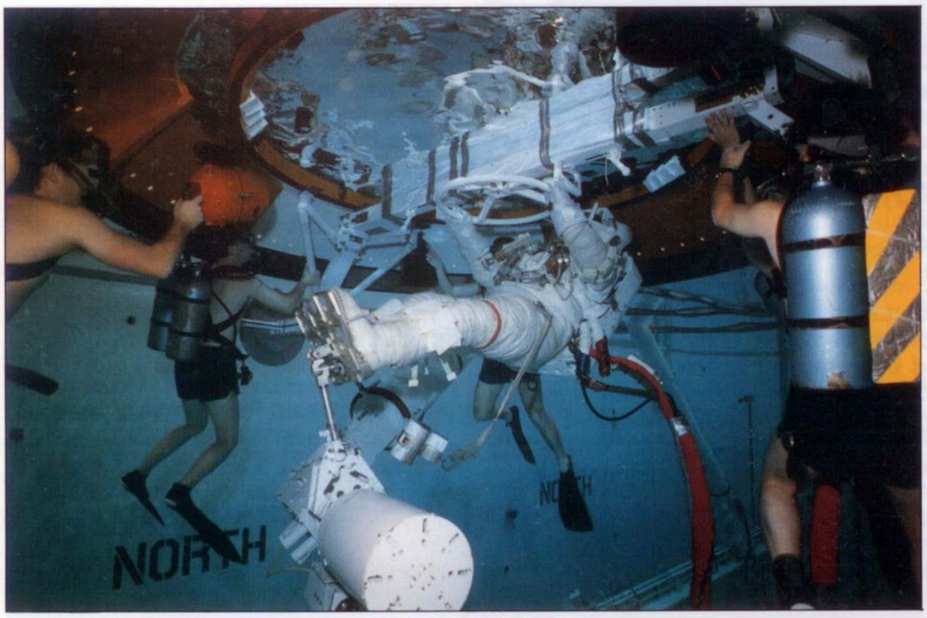
He mentioned the EVA crewmembers' individual numbers: 'I was EV1, Rick was EV2, Tom was EV4 and Kathy was EV3; and the way of telling that from any of the pictures is that EV1 always has red stripes on his legs and on the back of his life support system; EV2 has no stripes; and, in this case, EV3 had red stripes with white spaces along those stripes; and EV4 had red and white diagonal lines to make up the stripes on his legs'. The five Mission specialists also received individual numerical designations: Hieb was MS1, Bruce Melnick was MS2 and 'flight engineer' for ascent and entry, Thuot was MS3, Thornton was MS4 and Akers was MS5.

* * *

On March 5, 1993, Pierre Thuot received his third Shuttle flight assignment: as a Mission Specialist on the 14-day extended-duration STS-62 mission scheduled to take place in March 1994. During the mission, the crew of five will conduct microgravity and materials research experiments on the second United States Microgravity Payload (USMP-2), as well as NASA technology and space physics research on the second Office of Aeronautics & Space Technology (OAST-2) payload. USMP-2 hardware is located on a Materials Science Laboratory-style carrier in the orbiter's payload bay, while OAST-2 will be accommodated on a Hitch Hiker crossbay 'bridge' structure.

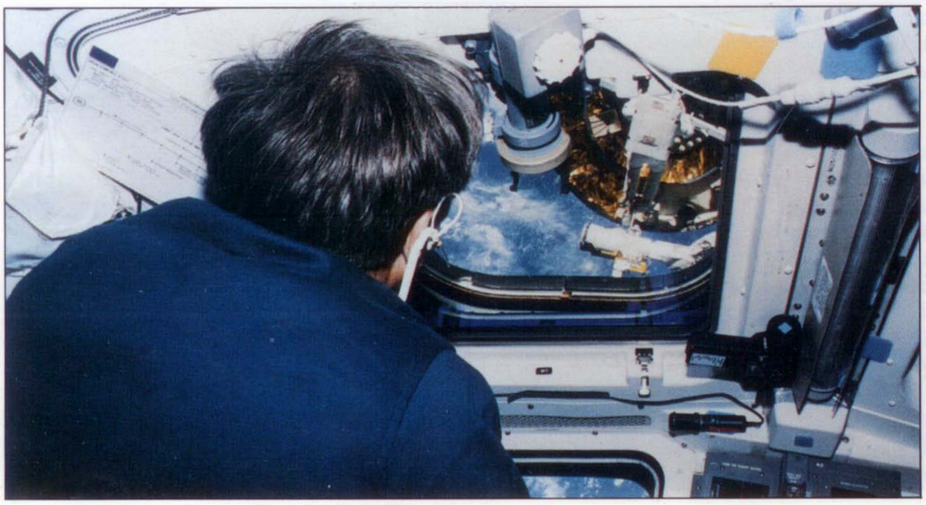
Pierre Thuot, a Commander in the US Navy, was born on May 19, 1955 in Groton, Connecticut and gained a Bachelor of Science degree in Physics from the US Naval Academy, in addition to a Master of Science degree in Systems Management from the University of Southern California. He joined the astronaut corps in July 1985 as a member of NASA's Group Eleven intake. Towards the end of the following year, shortly after the STS-51-L accident, Thuot completed his mandatory twelve-month training and evaluation phase which made him eligible for assignment to future Shuttle flights as a Mission Specialist. He received his first flight assignments in March 1989 as a Mission Specialist on the military STS-36 mission, which eventually flew in February 1990. Following his first flight, Thuot served as EVA Representative for the Astronaut Office, before being assigned to STS-49 in November 1990. ■

Pierre Thuot (left) and Rick Hieb in the white room at Launch Pad 39B only hours before the lift-off of Endeavour on its maiden voyage. NASA

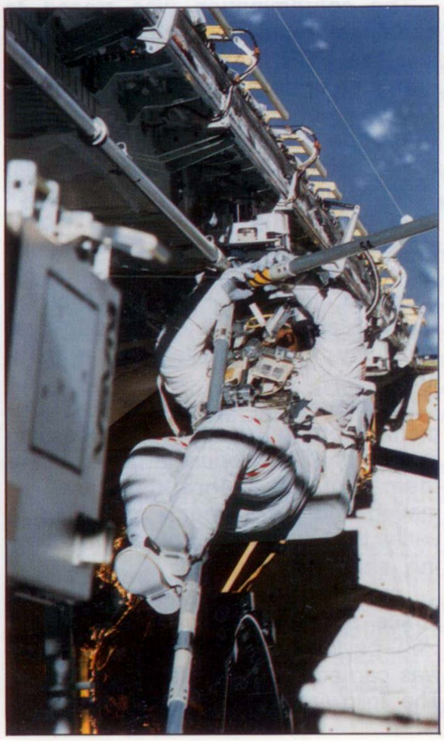


Pierre Thuot training for his STS-49 EVA in the weightless environment training facility at the Johnson Space Center, March 1991. NASA

Mission commander Daniel C. Brandenstein watches Pierre Thuot's second unsuccessful attempt to grapple the errant satellite using a capture bar device. NASA



Thomas D. Akers joins three struts together as part of the evaluation of EVA Methods of space station construction. The scene was recorded on 70 mm film by a fellow crewmember in the Space Shuttle's cabin. NASA



The STS-61 astronauts take a break from Terminal Countdown Demonstration Test activities and stand outside the orbiter Endeavour crew hatch at Launch Pad 39A. From the left are Mission Specialist Tom Akers; Mission Commander Richard Covey; Mission Specialists Kathy Thornton, Claude Nicollier and Jeff Hoffman; Pilot Ken Bowersox; and Payload Commander Story Musgrave. NASA

Pre-Launch Preparations for STS-61

Endeavour Switches Launch Pads

On November 4 and 5 1993, the STS-61 astronauts were busy with the Terminal Countdown Demonstration Test at Launch Pad 39A. The TCDT is a dress rehearsal of the launch and involves both the crew and the launch team. By this time the HST payloads had been moved to the launch pad but were still enclosed in protective covers. These were to have been removed for flight, however, after arriving at the launch pad it was noted that some contamination existed in the Payload Changeout Room (PCR) where the payload elements are housed for insertion into the shuttle payload bay.

The contamination was traced to sandblast residue which had leaked into the PCR. Launch Complex 39A had just undergone a refurbishment and some of the residue sand from the operation had worked through the ceiling joints of the PCR. It was decided to move the HST payloads back to a processing facility for a closer inspection to insure that no elements were contaminated and also to allow crews to clean the PCR and seal the room's ceiling and wall joints to prevent any further contamination intrusion.

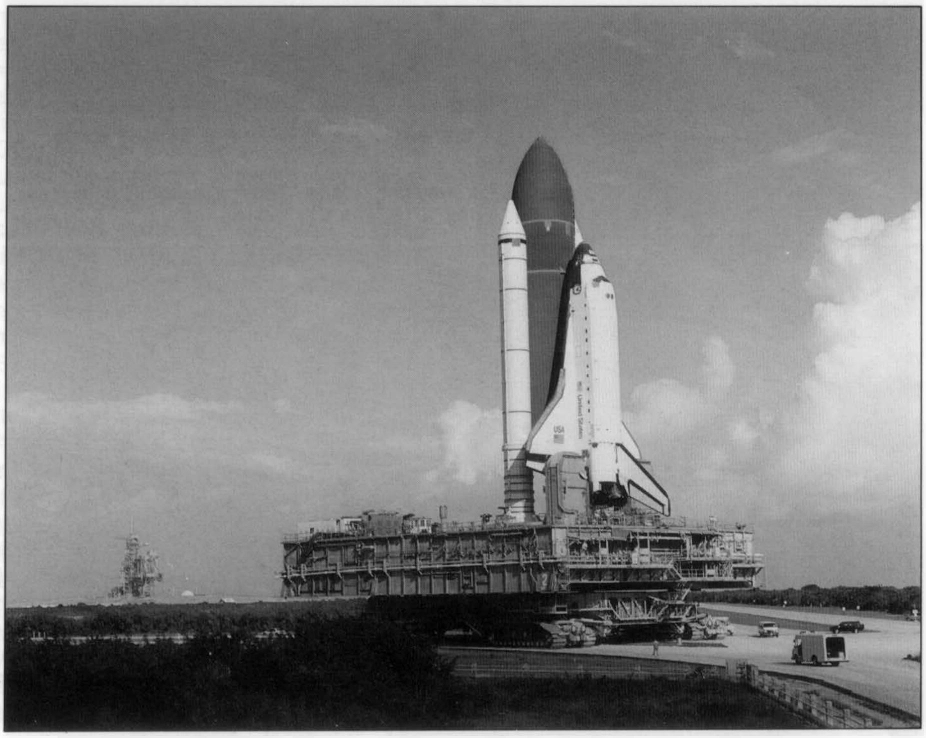
On November 4 the payload elements were returned to a processing facility in KSC's industrial area where their protective shrouds were removed and the elements inspected to verify they were not contaminated by the sandblast residue.

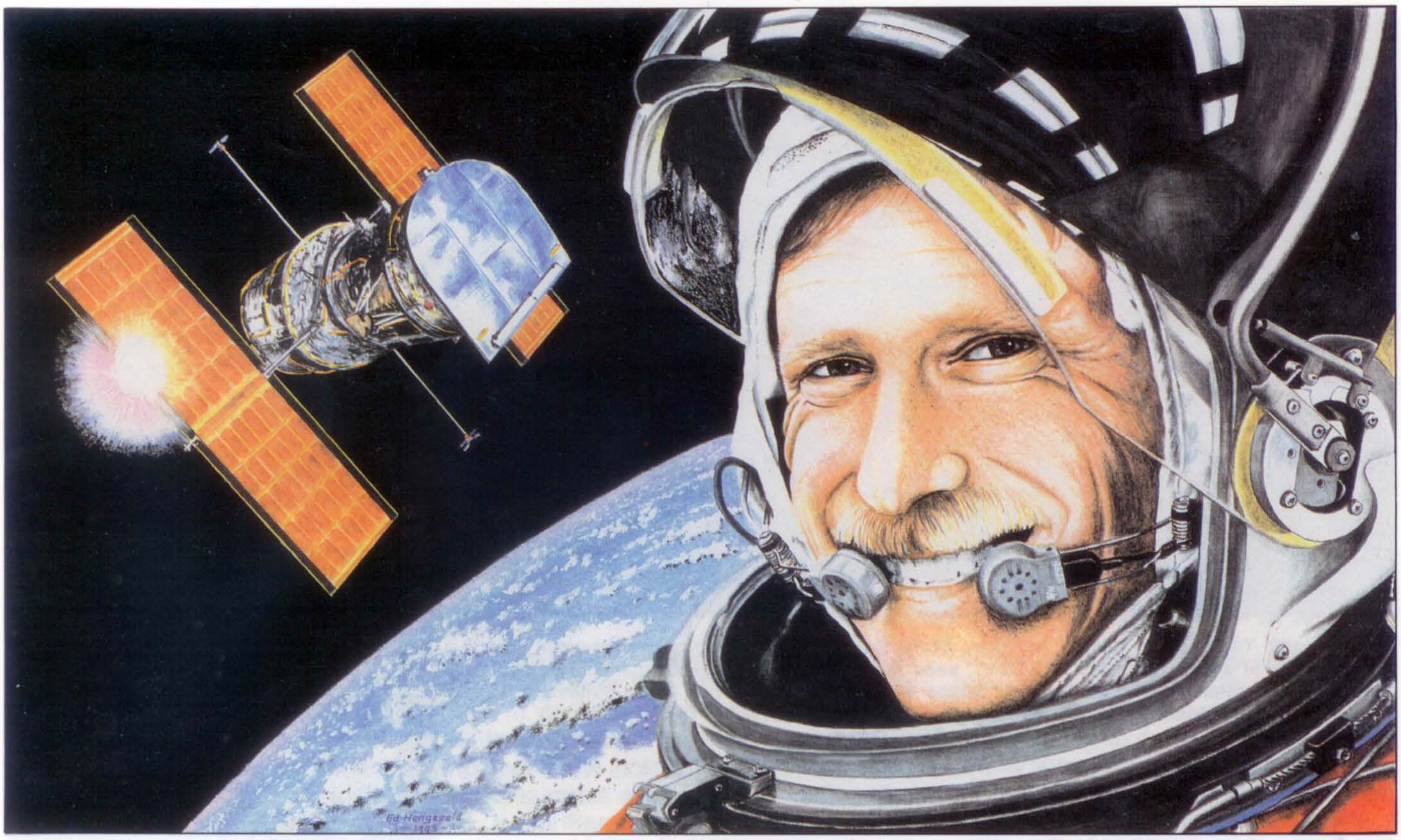
Launch pad operations with the space shuttle continued without the HST payload elements and the TCDT was carried out on November 4 and 5. The following week hypergolic propellants were loaded aboard Endeavour. In the meantime mission managers had reviewed the contamination issue and determined that the best course of action would be to switch launch pads. With the projected launch less than a month away this would allow the PCR cleaning, sealing and certification of Launch Complex 39B's PCR to be completed sooner than the sandblast-contaminated 39A's PCR. Hypergolic propellants were being loaded aboard Endeavour for the manoeuvring engines at pad 39A and this hazardous procedure would have delayed the PCR cleaning and sealing operation at pad 39A.

Accordingly, on November 15 the STS-61 space shuttle and its mobile launch platform left Launch Complex 39A, travelled back down the crawlerway leading to the VAB to the point where the crawlerway branches off to Launch Complex 39B, and then moved down the branch and arrived at Launch complex 39B. This was the first time in the history of the programme that a move of this exact nature had been made.

The payload elements joined the shuttle the following day and they were installed in the Launch Complex 39B PCR. Following their installation in the PCR the Rotating Service Structure later swung the PCR alongside the orbiter's midbody in preparation for installing the payload elements into the payload bay. *R.L. SCHUILING*

The space shuttle Endeavour is being "rolled round" from Launch Pad 39A to Launch Pad 39B. The rare pad switch was deemed necessary after contamination was discovered in the Payload Changeout Room at Pad A. The transfer began around noon and was completed about seven hours later. NASA





Ed Hengeveld, space flight historian and BIS Member , commemorates the STS-61 mission with this portrait of its commander Dick Covey and the Hubble Space Telescope. ED HENGEVELD 1993

Dick Covey Has Plenty to Smile About!

Astronauts Return Home after Refurbishing the Hubble Space Telescope

On December 13 1993, the US space shuttle Endeavour and its seven crew members landed to end their challenging 11-day mission to refurbish the orbiting Hubble Space Telescope. They touched down for a nighttime landing at the Kennedy Space Center, Florida to complete a nearly flawless flight. During the hour-long descent from space, ESA astronaut Claude Nicollier helped mission commander Dick Covey and pilot Ken Bowersox monitor the shuttle's cockpit displays.

Many consider the mission to have been the most complex since the shuttle began flying and the greatest challenge for NASA since the Apollo

Above: STS-61 Mission Commander Richard O. Covey is glad to be back on Earth after a highly successful 11 days in space. Endeavour made a smooth touchdown on Runway 33 at KSC's Shuttle Landing Facility at 12:25:33 am EST on December 13, 1993. NASA

Left: The Orbiter Recovery Convoy team swarms around Endeavour after its nighttime landing at the KSC. NASA

Left to right: Tom Akers, Claude Nicollier, Story Musgrave and mission commander Dick Covery. Four of seven members of STS-61, seen here framed by a spectacular Florida Sunrise, 6½ hours after arriving at Kennedy Space Center, prior to leaving Cape Canaveral Air Force Station for Houston Texas, Monday December 13, 1993.
PETER QUALTIERI, *THE WEST KENTUCKY NEWS*

moon landings more than 20 years ago.

After capturing the orbiting Hubble Space Telescope earlier in the mission and anchoring it in the shuttle's open cargo bay, the crew carried out a series of five arduous spacewalks - a US record for one mission - to install new optics, a new set of European solar panels, gyroscopes and other equipment in the 12.5 ton telescope.

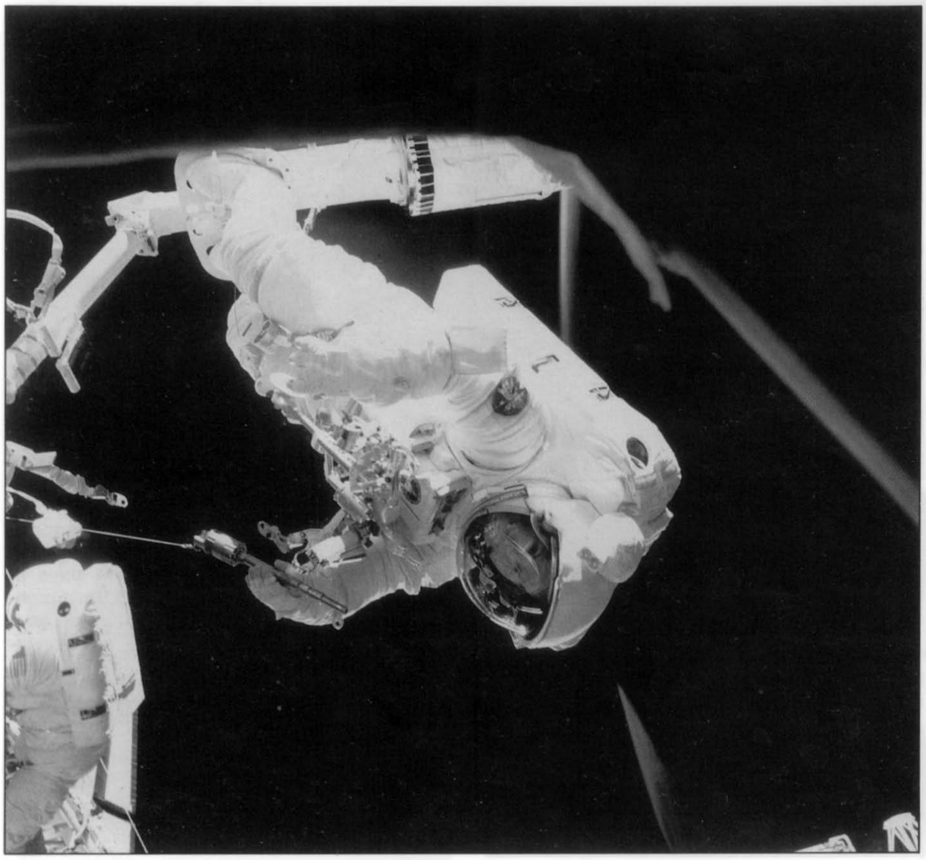
The four spacewalking astronauts, working in pairs on alternate days, completed everything they had set out to do during the mission.

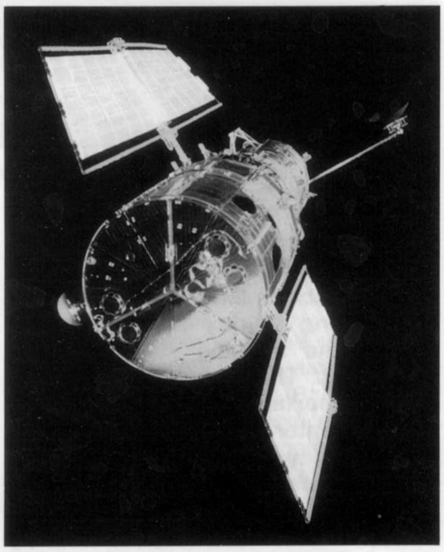
The refurbished observatory was then released on December 10 by Swiss astronaut Claude Nicollier from the end of the shuttle's mechanical arm to continue its 15-year orbital voyage to study fundamental mysteries of the universe. Commander Dick Covey said, "This was a particularly important international mission from the standpoint of our Swiss and European Space Agency crew member Claude Nicollier, who played an incredibly important part in the repair of the Hubble Space Telescope. If there was an unsung hero of this mission it would be Claude and his arm because without them we could not have worked the way we did and been as successful as we were".

After five weeks of fine-tuning from the ground, the repaired Hubble Space Telescope delivered its first new images of the universe amid expections that the search for black holes, which had previously been frustrated by the blurred image, would now be successful.

(Reports on the STS-61 mission and refurbished Hubble Space Telescope will appear in a forthcoming issue.)

There is no 'up' or 'down' in space! Kathy Thornton during her first STS-61 EVA is photographed by one of her crewmates from inside Endeavour as she services the Hubble Space Telescope. Thomas Akers is seen in the background. NASA

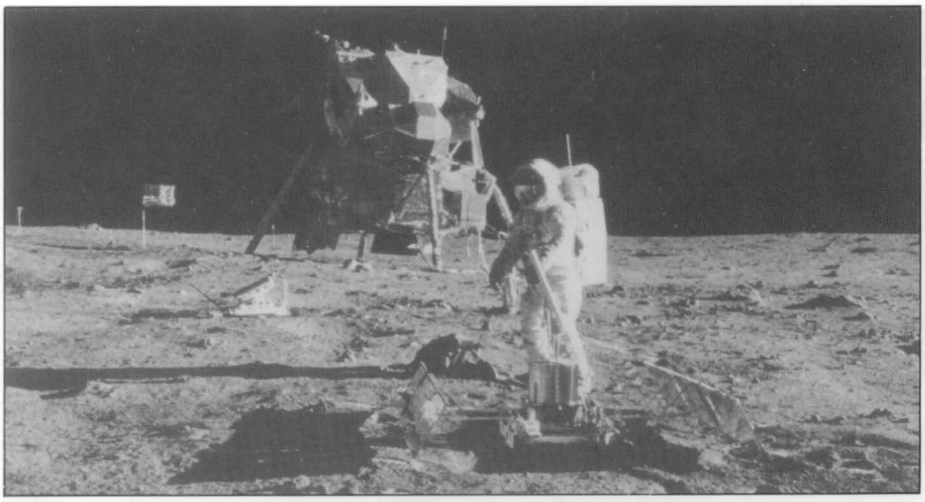




The Hubble Space Telescope begins its separation from Endeavour following a week and a half berthed in the space vehicle's cargo bay. NASA

The ability of the astronauts to repair the Hubble Telescope in space - the spacewalkers installed 11 new Hubble components - has boosted morale and demonstrated to many that a space station can be built.

The seven shuttle launches of 1993, culminating in the high-profile Hubble repair mission experienced many technical problems - including four launches aborted less than 30 seconds before liftoff - and bad luck with the weather. NASA needed 17 launch countdowns to achieve seven flights. It took only nine countdowns for eight launches in 1992. NASA closed 1993 with hopes of converting its success with STS-61 into political and financial momentum for the space station programme that is now planned in partnership with Russia. ■



Buzz Aldrin deploys the Early Apollo Scientific Experiments Package on the surface of the Moon during the Apollo 11 EVA activity. NASA

I Meet the Second Man to Walk on the Moon

After the Society's 60th Anniversary Banquet held in Hastings on Saturday 16 October 1993, our most distinguished and honoured guest Buzz Aldrin fielded questions from the many other participants. As the Society's President, it was my pleasure to act as host to our special guests and I had the privileged opportunity to meet the second man to walk on the Moon.

BY TONY LAWTON
President, BIS

Buzz originally derived his name from his astonishing restlessness and ability to work and has now legally adopted it. He still retains this vitality at the age of 63. A qualified engineer, he was selected as an astronaut in 1963. After the usual intensive training he first flew in space on the Gemini 12 mission in November 1966.

He was the lunar module pilot of Apollo 11, the first manned vehicle to land on the Moon, in July 1969. Neil Armstrong, the crew commander, was the first to set foot on our satellite and Buzz Aldrin joined him shortly afterwards. Here is a selection of the questions Buzz was asked about the Apollo mission:

Tony Lawton, BIS President chats with Buzz Aldrin at the SPACE '93 Banquet.

Did you have any experience that caused you to change your spiritual outlook?

No, but I offered a prayer of thanksgiving in commemoration of a safe landing and gave myself Holy Communion. (He was already a Church Minister).

Did you like the Moon - as compared say with Earth?

No, I did not like the Moon, it is an alien surface with no colouring apart from grey, black and white in various mixtures and shadings.

What worried you most?

That the lift off motor might not work properly and we would be marooned. There was no way at all out of that.

How did you feel about the descent to the surface?

I practised exhaustively and decided the best approach was a very shallow glide angle - as shallow as the fuel reserves would permit. This gives the greatest flexibility in avoiding boulders and small craters. It worked, for we were able to land close to our designated area with the module at an acceptably level siting and stance for take off.

What is Moonsoil like?

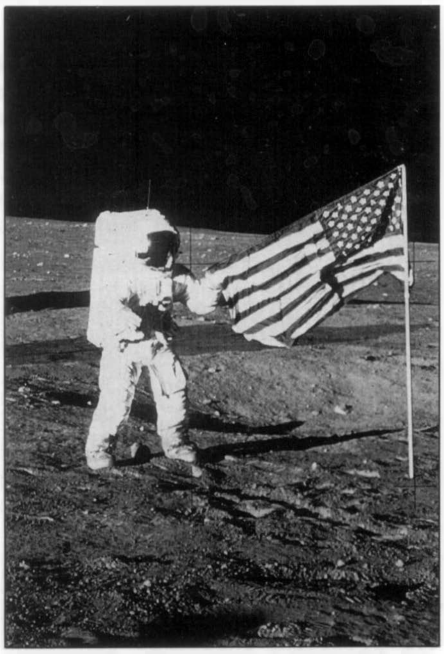
There is literally nothing like it on Earth. It is utterly devoid of moisture, but it is so finely packed that dust grains pack around the larger grains which in turn pack the larger pieces. There are no small cracks or cavities in Moonsoil.

This made it difficult to drill core samples - the core tube had its sharp edge ground on the inside. This merely packed the Moondust so hard onto the coring bit that the motor stalled and would have burned out if we had persisted. Later expeditions had the sharp edge outside and were able to take deep samples.

Also when we tried to put the flag on the landscape we could not drive the flagpole deeper than 3 or 4 inches. The soil just compressed underneath the base of the pole. Again, later expeditions had better flags!

Do you think the Moon could be a useful base for manned flight to the planets?

I have mixed feelings about that. Theoretically one could do all sorts of tasks - some because of the low gravity could be easier than on Earth. But my own feelings are that the alien nature of the materials (even common rocks and sand) combined with the extreme difficulties of working in a full lunar space suit mean that work by a construction team would be almost impossible by present means. There are many problems which need to be fully addressed apart from the physics of no water or free hydrogen.

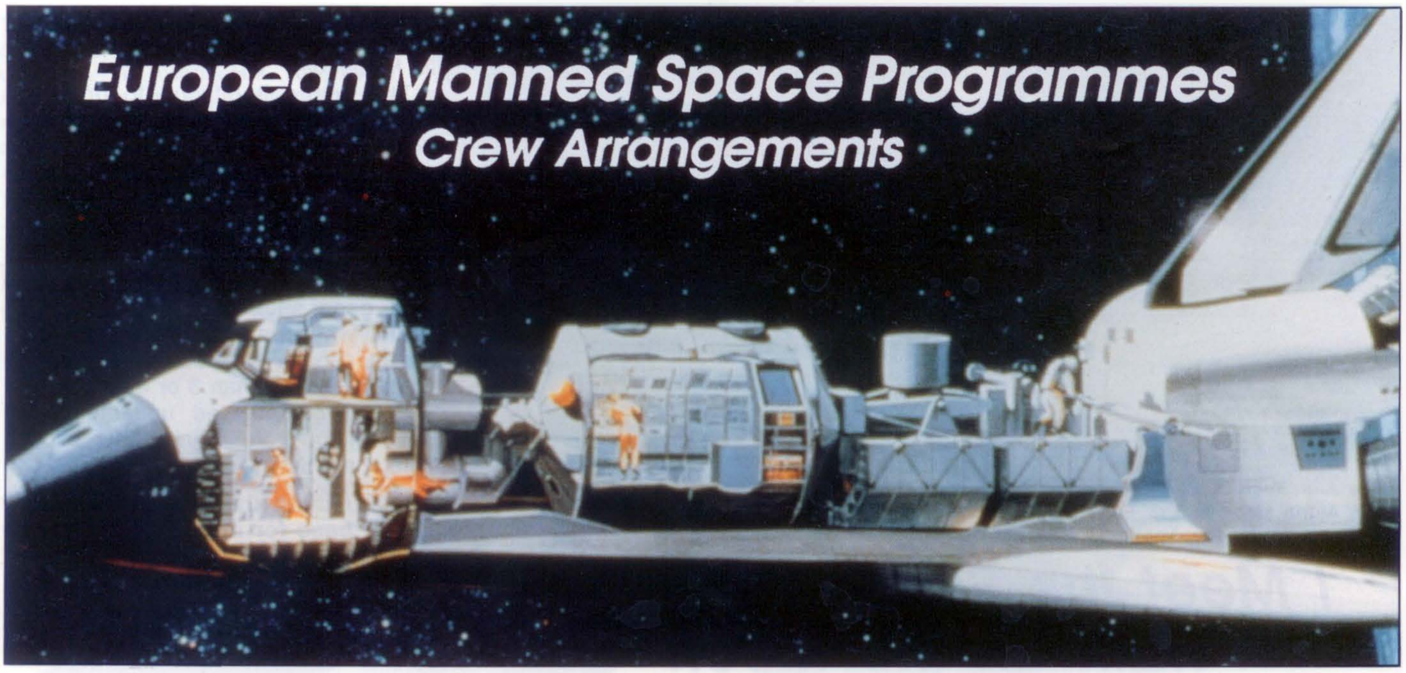


Planting the flag during the Apollo 11 mission. NASA

Perhaps the only useful material we may obtain from the lunar surface is helium 3 (He_3) which could be usefully used in a fusion rocket motor.

Such a motor would give us very useful Solar System flight with minimal danger from radiation.

I feel that we may ignore the Moon and go on to Mars where the climate - and presumably materials are a little more Earthlike. ■



Spacelab - Europe's manned laboratory. ESA

Europe is now committed to man-in-space though subject to many vagaries in funding and direction introduced by the changing political and economic environment. However, on the technical side, Europe under the aegis of the European Space Agency (ESA) is laying the foundations for future European manned activities. This article summarises the position to date and presents data on future cooperative activities planned as part of the US and Russian manned programmes.

BY D.J. SHAPLAND
Formerly Head of ESA Astronaut Office, Paris
and
F. ROSSITTO
Head of Astronauts Division, ESA-EAC, European Astronauts Centre, Cologne

Introduction

Europe's first man-in-space was Jean-Loup Chretien of France*. He was carried by the Soviet Soyuz spacecraft to Salyut 7 on 24 June 1982 and remained there for six days, performing scientific experiments before returning to Earth.

Spacelab, the first European-built vehicle for manned operations in space, represents ESA's first step in manned-space activities. The vehicle has a large, reusable, modular structure (4 m dia, 7 m long), providing all the necessary supporting equipment for the performance of man-tended experiments in the module and experiments directly exposed to space on the pallet. It is carried to orbit in the cargo bay of the Space Shuttle and remains there for the duration of the mission. Its first flight in November 1983 provided the first opportunity for an ESA staff member, Dr Ulf Merbold, to fly and work in space.

The experience provided by the construction and operation of Spacelab led to the evolution of European manned space flight based on the International Space Station and Mir scenarios. As regards the International Space Station, ESA undertook to provide an element, the Attached Pressurized Module (APM), based on the Spacelab concept through its Columbus programme.

Jean-Loup Chrétien - Europe's first man in space. ESA

European Man-in-Space

Table 1 provides a summary of space flights performed by Europeans to date. With no inherent manned launch capability, it illustrates how Europe has made use of the Soviet Salyut and Mir orbital stations and the US Space Shuttle Orbiter and Spacelab combination.

The total flight time represented is approximately 170 man-days in space. The large time gap evident in the Space Shuttle missions during the period 1985 to 1992 reflects the grounding of the Shuttle fleet due to the Challenger disaster.

Apart from ESA personnel, individual Member States - Austria, Belgium, France, Germany, Italy and the UK have been able to fly their own astronauts on NASA or Soviet/Russian systems. In the majority of cases the flights were undertaken in support of scientific activities and one mission even included an EVA sortie.

Future activities are summarised in Table 2. Although changes may occur nearer the time of missions, those listed are presently under training. Although the collective word man-in-space has been used throughout this article, it should be pointed out that two of the astronauts named in Tables 1 and 2 are women (Sharman and Deshays).

Regarding Table 1, it is particularly interesting that C. Nicollier (also an astronomer) has been assigned by NASA to the important task of servicing the Hubble Space Telescope. Also, ESA-Russian cooperation is evidenced by the planned EUROMIR missions using ESA personnel.

Both Tables 1 and 2 show the increased importance of the role of

*Since many of the former-USSR States can be considered as European, the authors faced some difficulty with terminology in this article. For the sake of clarity, the term European refers to W. Europe whereas the Soviet and Russian efforts are considered as a separate entity. A further complication is introduced since Sigmund Jaehn of the former German Democratic Republic (now part of Germany, an ESA Member State) made a space flight in August 1978, as part of the Soviet programme.

Presented at Space '93, Hastings, October 1993.

Mission Specialist, rather than Payload Specialist, given to ESA astronauts by NASA and the EVA activities scheduled in the Mir missions. It is clear that, by the late 90s, Europe will have accumulated considerable experience in the field of manned space activities.

European Astronauts Centre

The responsibility for early astronaut activities within ESA was assigned to the ESA Astronaut Office in Paris. As the size of the corps and the aspirations of Member States grew, it was decided to establish a European Astronauts Centre (EAC) in accordance with ESA's Council decision to set up a manned in-orbit infrastructure and to use Member State resources wherever possible. The EAC is located, as an ESA establishment, within the German Aerospace Research Establishment DLR in Cologne (Germany) and uses many of the facilities already existing at DLR. EAC is responsible for the selection and training of astronauts from all Member States under standardised conditions and coordinates all European astronaut activities. It represents ESA *vis-a-vis* its counterparts in NASA, Russia, Japan and Canada.

Wherever possible, existing Member State facilities are used with the Centre itself providing basic training (lectures and hardware), medical surveillance and training and the Neutral Buoyancy Facility. in addition certain training, relevant to specific missions, is carried out in Russia or the USA.

Shuttle/Spacelab Flights

A Memorandum of Understanding (MOU) between NASA and ESA (then ESRO) was agreed during early negotiations on the Spacelab programme. This MOU stated that it was contemplated that a European crew member would be included in the flight crew of the first Spacelab flight. This concept was repeated in the Agreements between Member States' governments and NASA, leading eventually to the flight of Ulf Merbold during Spacelab's first flight. Subsequent ESA flights (Table 1) were on an *ad hoc* basis. The use of Member State astronauts was agreed on a bilateral basis between NASA and the Member State concerned.

Most of the European astronauts flown in Shuttle/Spacelab so far have been classified as Payload Specialist when the astronaut performs experiments devised by experimenters using the laboratory. One of the first Spacelab flight astronaut candidates (Nicollier) was fully trained as Mission Specialist by NASA and has flown in this capacity during the mission used to deploy Eureca. NASA will make more use of ESA Mission Specialists in future.

Table 1: Summary of Flights to Date.

Vehicle: Mission	Date	Name		Role/Function
Salyut-7	06/1982	J.L. Chrétien	(F)	RC
Spacelab: SL-1	11/1983	U. Merbold	(ESA)	PS
Shuttle: 51-G	06/1985	P. Baudry	(F)	PS
Spacelab: D-1	10/1985	R. Furrer	(D)	PS
		E. Messerschmid	(D)	PS
		W. Ockels	(ESA)	PS
Mir: Aragatz	11/1988	J.L. Chrétien	(F)	RC/EVA
Mir: Juno	05/1991	H. Sharman	(UK)	RC
Mir: Austromir	10/1991	F. Viehboeck	(A)	RC
Spacelab: IML-1	01/1992	U. Merbold	(ESA)	PS
Shuttle: Atlas-1	03/1992	D. Frimout	(B)	PS
Mir: Mir-92	04/1992	H.U. Flade	(D)	RC
Mir: Antares	07/1992	M. Tognini	(F)	RC
Shuttle:Eureca/TSS	07/1992	C. Nicollier	(ESA)	MS
		F. Malerba	(I)	PS
Spacelab: D-2	03/1993	H. Schlegel	(D)	PS
		H.U. Walter	(D)	PS
Mir: Altair	07/1993	J.P. Haignére	(F)	RC
Shuttle: HST Servicing	12/1993	C. Nicollier	(ESA)	MS

(A) Austria (B) Belgium (D) Germany
(F) France (I) Italy (UK) United Kingdom
RC: Research Cosmonaut PS: Payload Specialist MS: Mission Specialist

International Space Station

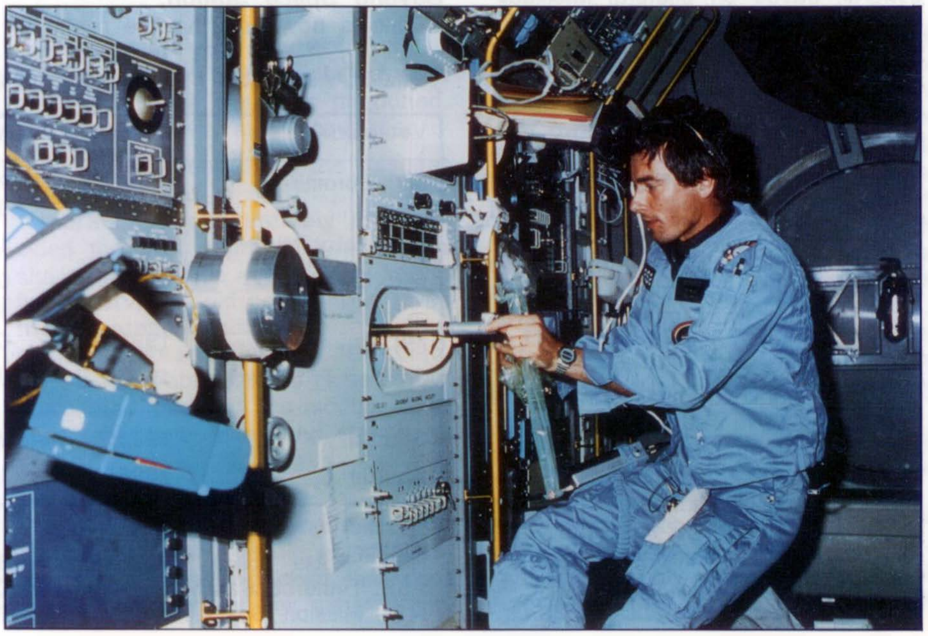
Following the inter-governmental Agreement between the USA, Japan, Canada and the European Member States of ESA for participation in the Space Station programme, a MOU between ESA and NASA was established. This gave ESA the right to provide personnel to serve as members of the Space Station crew. The MOU also provided for cooperation in assigning crew members and the development of a code of conduct for the Space Station crew.

For the exploitation phase, the roles suggested for ESA crew members was those of Station Operator, responsible for Space Station systems, and Station Scientist, responsible for payload operations including EVA. The allocation of the role of Payload Scientist, a non-career post, is also being considered.

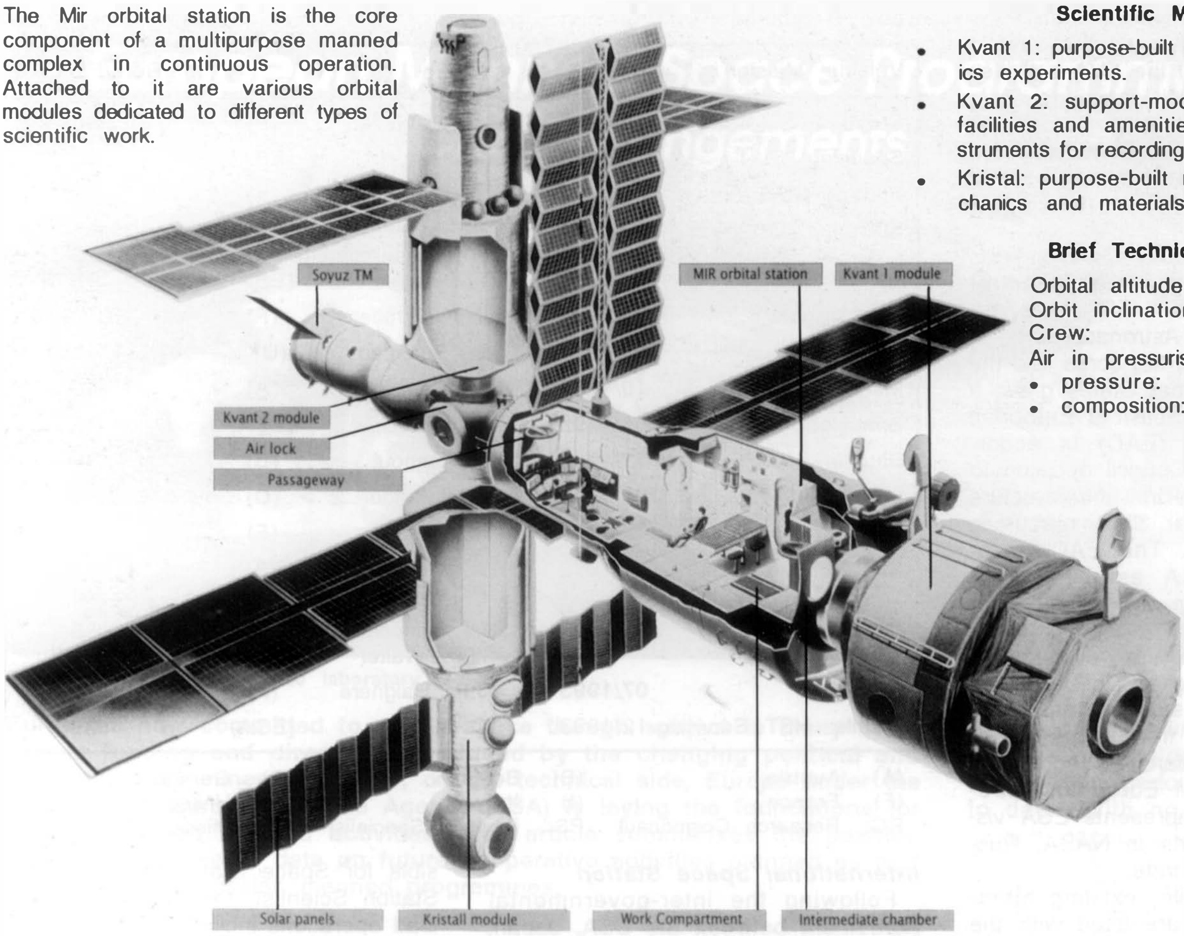
As regards astronaut training for missions, ESA would be fully responsible for the basic training of its astronauts and would participate with other partners involved in advanced and mission training.

In the interim, NASA has offered opportunities for a number of astronuts to be qualified as Mission Specialist on the Space Shuttle. This has been duly implemented in the so-called

Dr Ulf Merbold loads the gradient heating furnace during the first spacelab flight. ESA



The Mir orbital station is the core component of a multipurpose manned complex in continuous operation. Attached to it are various orbital modules dedicated to different types of scientific work.



Scientific Modules

- Kvant 1: purpose-built module for astrophysics experiments.
- Kvant 2: support-module containing crew facilities and amenities. Also includes instruments for recording images of the Earth.
- Kristal: purpose-built module for fluid mechanics and materials experiments.

Brief Technical Data

Orbital altitude:	300-400 km
Orbit inclination:	51.60
Crew:	2 to 6

Air in pressurised compartments:
- pressure: 450 - 970 mm Hg
- composition: normal terrestrial atmosphere

The Mir orbital station. ESA

1992 International Class. As a result the ESA astronaut corps now contains two new Mission Specialists (Cheli and Clervoy).

Mir Missions

Many European countries (France, UK, Austria and Germany) have obtained flight opportunities offered by the former USSR and the Commonwealth of Independent States (CIS) for national astronauts to visit the Salyut and Mir stations. These visits were, in general, based on bilateral inter-government Agreements for scientific cooperation, followed by contractual arrangements with the flight services provider.

ESA is also preparing for two missions to the Mir station which have been designated EUROMIR-94 and EUROMIR-95 and will be conducted within the framework of the Columbus Precursor Flights Programme. These missions offer European scientists long-duration, man-assisted operations in space (30 days in 1994 and 135 days in 1995). ESA can gather important, long flight experience, invaluable for the future use of the Space Station. The scientific programme for EUROMIR-94 is devoted mainly to Life Sciences and in preparing for the more challenging EUROMIR-95. Four ESA astronauts are presently training at Star City. Two will be qualified as Research Cosmonauts and two as Onboard Engineers. The latter will also receive EVA training. The scientific payload training will be performed in Europe with the participation of the whole crew. The final assignment (one ESA crew member per mission) will be made about 8 months before mission start. Back-up crew members will act as Crew Interface Coordinators, supporting the scientific activities from the Mission Control Centre in Kaliningrad.

Beyond Space Station

This is now entering the realm of wishful thinking but, having established a pool of experienced astronauts and having demonstrated a satisfactory and reliable training scheme, Europe will be able to participate in any manned mission that is agreed. Future missions will almost certainly be of an international nature and exciting possibilities such as Advanced Space Station, Lunar Base, Mars Base and Asteroid Landing projects spring to mind.

Europe has staked its claim to be represented in any international crew chosen for such an exciting venture.

Table 2: Astronauts in Training for Planned Missions.

Vehicle/Mission	Date	Name		Role/Function
Mir: Euromir-94	09/1994	P. Duque or U. Merbold *	(ESA) (ESA)	RC
Spacelab: IML-2	1994	J.J. Favier	(F)	PS
Mir: Euromir-95	08/1995	C. Fuglesang or T. Reiter *	(ESA) (ESA)	OE/EVA
Mir	1995	C. Deshays	(F)	RC
Shuttle: TSS Reflight	1995	U. Guidoni	(I)	PS
Shuttle	1996/7	M. Cheli	(ESA)	MS
Shuttle	1996/7	J.F. Clervoy	(ESA)	MS

* Prime to be assigned

HST: Hubble Space Telescope
TSS: Tethered Satellite System
MS: Mission Specialist

PS: Payload Specialist
RC: Research Cosmonaut
OE: Onboard Engineer

A view of atolls in the Indian Ocean taken from Mir during the Juno mission. JUNO

A Conversation with Helen Sharman OBE

Like many explorers who have gone before her, Britain's first astronaut, Helen Sharman, has published a chronicle of her travels. Her new book "Seize The Moment", written in collaboration with Christopher Priest, is an account of the roller-coaster ride which took the former food technologist from her job in Slough to the heart of the Soviet Union; and then on to a six day stay in that country's most exclusive guest house - the Mir orbital station. While the book looks back on past events, Helen herself has her gaze fixed firmly on the future. As this interview with BIS member *Darren Burnham* shows, her main preoccupation now is to harness the interest generated by her flight as a means of stimulating greater public awareness of the role and importance of science and space technology to modern society.

Having given many talks all over the country, you are probably in a good position to judge the mood of the nation when it comes to space. In your experience is the British public sceptical about the benefits that space can offer?

I think the British public is very interested in space flight and would like very much to know more about what benefits it could give to people on Earth. It is something that we have had very little access to, and as such people have had little information and would like to know more about it.

Do you think that the Juno mission has done anything to change people's attitudes towards space in this country?

I think it really brought space to life for British people because for so long it had just been something that other nations did. Suddenly it put Britain on the manned space flight map. It gave British people the chance to see actually what kind of things can be done in space, and it gave me the opportunity to take on a number of other aspects that relate to space: to talk about scientific matters that either come out of space or are very interesting but do not necessarily have anything to do with space. People suddenly become interested when they realise that it is very much a part of their lives when they never thought it was or could be.

You have done much to focus on the educational aspects of the Juno mission. Why are such educational activities important to you?

I have done a lot of work educationally. I started out with young people when I first came back from Russia and now I am doing more work with older people. I do not tend to call it educational because sometimes that smacks of teaching people things, and I do not think I teach anything; but I can certainly make people much more aware of their surroundings, things that happen every day that we normally take for granted, like breathing. We do not necessarily think that we rely on convection to breath. In space you suffocate unless you have artificial convection and you have to circulate the air in the spacecraft to remove the carbon dioxide from in front of your face. That suddenly brings to life a whole series of physical principles that can be boring and dull when taught at school.

So you really see yourself as a medium between the scientists, perhaps in their ivory towers, and ordinary people in the street?

I have been very lucky in that I had the opportunity first of all to study science and enjoy it for myself and then, having come back from space, I had the opportunity to learn how to communicate. I started by communicating what I had done in Russia and in space, and then I learnt how to communicate science. Scientists often do not get that chance to learn how to put their ideas across to people. I am one of the lucky ones who has been able to learn both science and communications. I can quite easily talk about scientific principles but, more to the point, I enjoy doing it. It almost seems like a dream come true for me to see a need for something, to see people wanting me to do it, and for me to enjoy doing it at the same time.

The young, in particular, seem to have great enthusiasm for space. What do you think it is about space travel that they find so appealing?

First of all it is what space and astronauts do for the imagination. Then, what I think really makes them interested, when you get to talk about it, is that it is part of everyday life. Space is all around us. The fact is that we have this little thin layer of atmosphere separating us from it, but it is only so thin. When I talk to children I find that they understand about telephone communications and the fact that we use satellites - they use them in schools now. They often have satellite television in their homes - so by the use of space technology they understand how much a part of everyday life it is. I also let them realise what it is really like to be in space: what it is like to feel weightless. For instance, I have just slung my jacket over this chair and you do not do that if it is weightless because it could not stay there. You do not drink out of cups. Young people suddenly start to analyse much more what is around them on Earth and to look at it with new eyes. You see them question things that they have taken for granted for all their lives. It just brings a bright spark in their eyes, and you cannot let that rest.

Some critics have said that the 'edu-

cational' aspects of space are somewhat illusory in that young children only aspire to become astronauts when such opportunities may not be there for them in later life. Do you think that there is an inherent danger of setting them up for disappointment?

I never tell children to become astronauts. There is nothing wrong with aspiring to do anything, and there is nothing wrong with dreams. In fact, that is what makes people great in many respects, because when they have a dream, they have a goal to aim at. What I do is tell children how important science is, but not by saying to a class "Right I'm going to teach you the importance of physics" at which they would turn off straight away. They can learn about science by talking about something that is interesting to them. A lot of children are turned off music because they are taught the virtues of Bach at the age of eleven. It does not mean anything to many eleven year olds to learn about Bach, but it does mean something to them if they can learn about music that they can relate to, music that they hear everyday. Once they have the interest and a basic grounding they learn so much more quickly.

The four Juno candidates pictured during the live television programme to select the final two. Left to right are Helen Sharman, Timothy Mace, Clive Smith and Gordon Brooks.

Helen Sharman undergoes weightlessness training on a parabolic air flight. JUNO

Recovery team at the Soyuz TM-11 capsule after landing on May 26, 1991 JUNO

What long term benefits do you see arising from the Juno mission?

The aims of the mission, initially, were to put the first Briton into space, to go with the Soviets, and to do experiments in space. All three aims were achieved. I think that the long term benefits for Britain are that there was a Brit in space and it was a wonderful venture in Anglo-Soviet relations - specifically at that particular time. I flew in May - just before the coup of August 1991 - so it was a wonderful time, a very interesting time.

The experiments that I did will be of use and of value to mankind in the future, though I was very sad not to be able to do British experiments. That was something that could have been of great value to British scientists and of immediate value. Unfortunately, because the commercial part of the mission failed the British experiments were not undertaken.

I was very pleased to be able to do experiments but, more than that, it gave me personally this new opportunity to be able to enthuse and interest people in science.

How do you plan to use your position as Britain's first astronaut to continue promoting British science and British space activities?

I very much want people to understand more about what Britain does in space. We do not fund any manned space activities but we do a lot of other things - mainly remote sensing. I know that, to many people, manned space flight is often the most interesting part of space because it is of greater personal relevance as they can imagine themselves being in that position. By talking about space you can get people hooked and make it interesting, because it is. I have not met one person who has said that he or she is not interested by some aspect of space.

Before the Juno mission came along you were working in science but, as far as space was concerned you were very much an outsider. What is it about space that has convinced you that you should continue to lend your support to its promotion?

As you quite rightly say I started off as a scientist and never thought about being an astronaut or having anything to do with space. It caught my imagination and it is going to catch other people's too. All the things that I am doing now have been made so much easier because of the public recogni-

tion that I received. Astronauts do have - rightly or wrongly - some sort of 'kudos' if you like, some sort of credibility which sets them aside from other scientists and, because of that, I have an opportunity that I should not miss.

Being in the public eye has obviously brought about many changes in your own life, but if the opportunity for the Juno mission were to come around again would you go through it all again?

I would do it again without any hesitation. Any job-change changes you as a person. You go to a different part of the world and look at the way other people live and that changes both you and the way you look at life. For me, it was a serious job change. I am now doing another job. My life has changed but, as a person, I am still basically the same kind of person. I might think slightly differently and value things differently.

I used to work for Mars Confectionery and being young and single I wanted to earn lots of money, to buy a bigger car, a bigger flat and more expensive wine. Living in Russia taught me what was important in life. People are important. It is relationships, friends, family that count, and in that respect I live my life slightly differently. I do not spend my every working day striving to earn money. I need money, as we all do, but it is more important to me to have good relationships with my friends and family. Apart from that I am, basically, the same person.

It is very important to have a goal to aim for, and a path in life in which you feel comfortable, but that path must not get so deep that it becomes a rut, nor the goal become so focused that you cannot take on other opportunities as they come by. My goal was, I suppose, earning lots of money, and my path was working as a technologist in Mars Confectionery, something that I enjoyed very much. But suddenly this opportunity of going to Russia, learning how to be an astronaut and going into space appeared. Goodness knows why I applied because I never thought I had a chance of actually doing it, but it has become part of my life now and I do not feel any different as a person because of it.

Your outlook on life has changed though. To what extent has going into space been responsible?

Being in space really just confirmed for me what living in Russia had told me about the importance of people. There was only perhaps one more slightly stranger moment. We had always been asked - particularly by journalists "Oh isn't it going to be scaring" and "Aren't you scared of it blowing up on the launch pad" or something. As a scientist you tend to look at things in a reasonably logical way and you say 'Well OK, it has a risk. I don't know what that risk is as it hasn't happened so many times for me to get a good statistical analysis of it, but it's probably not very much more risky than crossing Piccadilly Circus on a busy Saturday afternoon'.

The night before we had to return back to Earth I remember desperately trying not to go to sleep. I wanted to keep looking out at the Earth when I knew that I was not going to be able to do that again. I remember watching the Earth go by and thinking that 'Tomorrow is probably going to be the most dangerous day of all my life'. The journalists had all thought about blowing up on launch but I knew that the landing was more dangerous and, for a really strange reason, I was not scared. I did not expect to die and yet I knew that if I did I would not be terribly upset or miffed: it would just be OK. I had had a wonderful time in space, I had done all of these things that I did not have the opportunity to do six months previously. I could do things up there that I had not been able to do on Earth. I had had a great time in Russia and made lots of friends. I remember looking further back as well, all the other things I had done in life - a pretty ordinary kind of life really but I had enjoyed it; I had laughed a lot, I had cried, I had experienced things, I had met different people, I had done different things. 'If I die tomorrow', I thought, 'it is alright' - it was as though I had come to terms with my own mortality.

Being in Russia seems to have had almost as great an impact on you as the actual act of going into space?

Well I was in Russia for eighteen months and was in space for only eight days. I learnt a lot being in Russia, partly because I was suddenly very separate from the society that I had known and grown up in. The people in Russia taught me a lot, at first because I did not even understand the language, let alone the culture, and it took a long time to understand that properly, probably nine or ten months, maybe a little more, living amongst them to understand properly what was important to them and ultimately important to me.

In recent months we have seen a coming together of the US and Russian space programmes. Do you think that the Juno mission and also those of other Western cosmonauts from nations such as France and Germany has helped bring about the day when the two major spacefaring nations can seriously consider close cooperation?

It has certainly made the Russians much more aware of what has gone on in the West, how different our cultures

Helen Sharman with a scientific experiment aboard the Mir Space Station during her historic eight-day mission. JUNO

are and the difficulties in working together. On the other hand, there are the benefits that we can gain from each other and the fact that the West wants the Russians. Ultimately, it is a political and economic process as both NASA and the Russian Space Agency desperately need each other. Neither can really afford to keep its own space programme going properly. The European Space Agency has always relied upon either NASA or Russia for its manned space programme and also for launching some of its unmanned satellites. It would be a dream come true to have a world space agency and a world space station that all could use, for all to benefit from and ultimately cooperate in.

My main worry is that it will become so bureaucratic that it will be unmanageable.

Are you optimistic about the future of space activities on a global scale?

Yes. Space activity will continue: certainly unmanned space activity, from which we are reaping benefits globally. ERS-1 has been wonderfully valuable. We are getting so much data, more than we can actually cope with at the moment, which is more our fault than that of space.

The manned space programme is also ultimately useful, on a much longer term basis, just like pure science. We all agree that science has to be funded and that pure science should be researched. Life is a compromise and you have to put money into hospitals and schools and life on the streets as well as life in space. But, it is a politician's choice. ■

Space Center

Space Center Houston - the new visitor centre located close to NASA's Johnson Space Center.

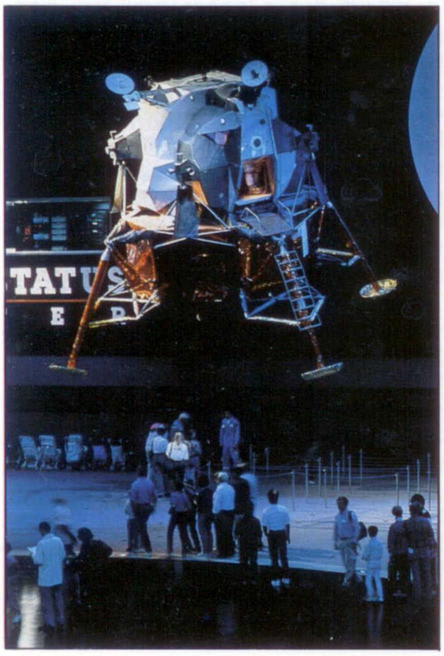
The latest in state-of-the-art space visitor centres opened for business in October 1992 on the south-west corner of NASA's Johnson Space Center, some twenty-five miles south of downtown Houston. Space Center Houston, the new visitor centre for JSC presents the extraordinary story of human space exploration from the early Mercury flights to the present Space Shuttle and beyond. Designed by Walt Disney Imagineering and produced by BRC Imagination Arts this 'visitor facility of the 90's' is being billed as the closest thing to space on Earth.

Space Center Houston is composed of six main theme areas which can be tackled by the visitor in any order.

The $75 million facility which was constructed in only fourteen months presently covers an area of 40 acres although 123 acres are available for future developments. Over 350 full and part-time staff are employed at Space Center Houston in operations, administration and food service and it is estimated that some two million visitors will spend between four and six hours at the centre each year.

In July 1986 the non-profit Manned Space Flight Education Foundation was chartered to finance, construct and operate what was to become Space Center Houston. The company, which owns the centre, is governed by a thirteen member Board of Directors which includes NASA astronaut Charles Bolden. President and chief operating officer is Harold Stall, Director of Public Affairs at JSC. The centre has attracted several sponsorships for its six major venues. They pay an annual fee to offset operating costs and in return receive recognition as sponsors for their respective venues.

Suspended in front of a huge lunar mural is this full-size Apollo lunar module.



Space Center Plaza

This is the large central atrium into which visitors enter after arriving at the centre. It is here that visitors are briefed by engineers, scientists or astronauts from nearby JSC through video presentations and by in-person appearances. Directly across the central plaza is a full-scale Space Shuttle nose section mock-up protruding from a NASA hangar which allows guests a close look at an orbiter's crew compartment in the post-landing configuration. The mock-up, named 'Adventure', has an actual piece of 'flown' hardware on display - one of the nose-gear tyres was flown aboard Challenger on STS-41B in February 1984 and made the first Shuttle landing at the Kennedy Space Center.

Suspended in front of a huge lunar mural backdrop to the right of 'Adventure' is a full-size Apollo Lunar Module in the landing configuration.

Starship Gallery

This theme area tells the story of thirty years of human spaceflight. Its Destiny Theatre features the 15 minute film 'On Human Destiny' which highlights great moments in space exploration. Around the gallery, visitors can walk through a chronological exhibit of historical space artifacts. Included are the MA-9 capsule Faith 7, Cooper and Conrad's Gemini 5, the Lunar Test Article Training Vehicle, a Lunar Rover trainer, the Apollo 17 command module, the huge Skylab trainer (so large in fact that the centre was built around it) which is displayed horizontally and the ASTP docking module trainer complete with a Tom Stafford look-alike mannequin.

At the far end of the gallery is located the 'lunar landscape' exhibit. Gemini, Apollo and Shuttle astronaut John Young was technical consultant for this display which contains a realistic scene of Apollo astronauts working on the lunar surface. Next door in the 'lunar vault' is the world's largest display of moon rocks and includes a lunar sample which can be touched by visitors. Located in the lunar display area is the lunar growth chamber project. Local high school students are

Space Center Houston's largest exhibit - the massive Skylab trainer. 'Starship Gallery' was built around this exhibit.

making use of simulated lunar soil to explore the use of different types of vegetation for enhancing safe and reliable lunar life support systems. The students are working under the guidance of scientists from JSC's Life Support Systems Branch.

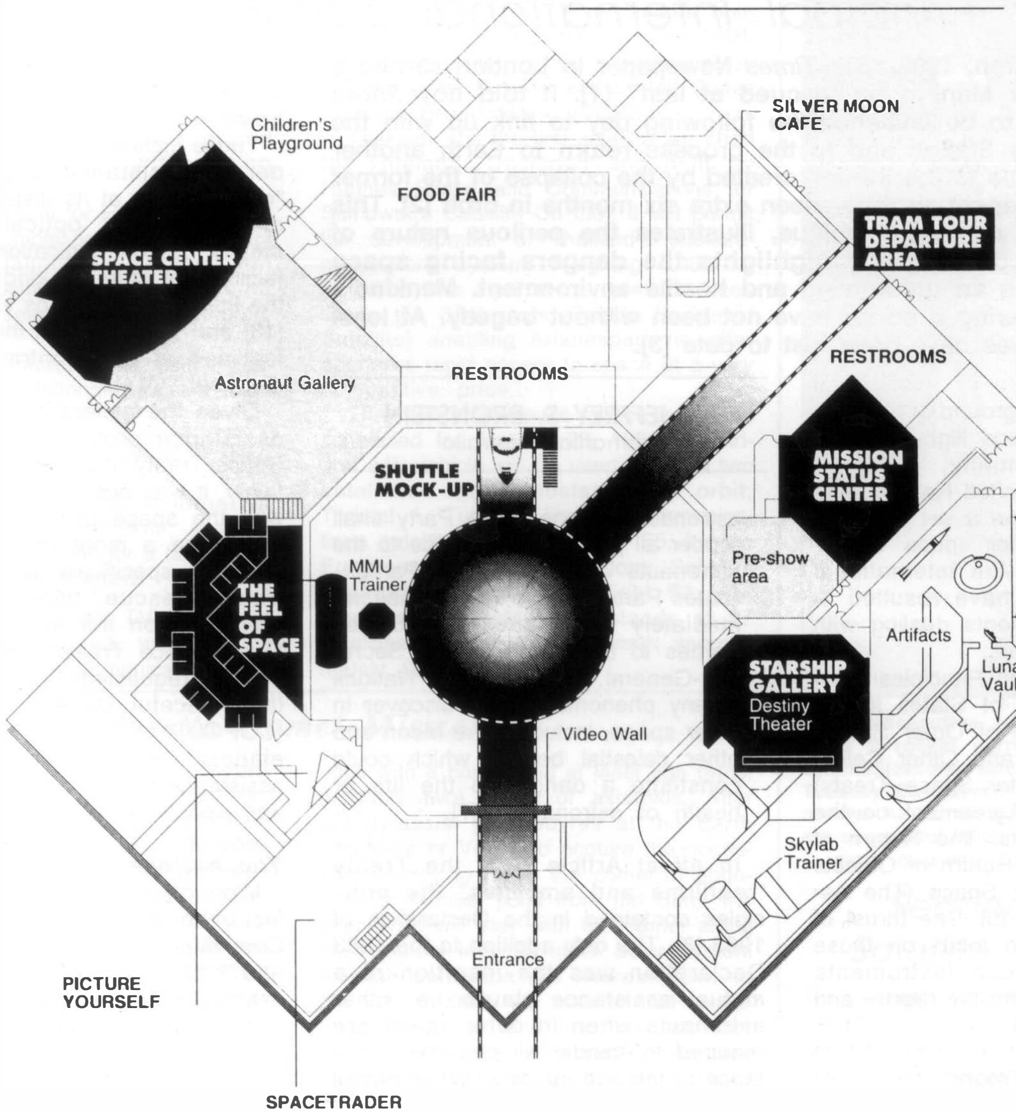
Mission Status Center

This area allows visitors to experience the sights, sounds and feel of JSC's mission control through the use of video displays. This venue allows up to 240 visitors for each presentation to listen in on communications between mission control and astronauts in orbit or to view real-time broadcasts from astronauts participating in ground-based training including activities in JSC's Weightless Environment Training Facility (WETF). Launches are also relayed live from KSC. One of the centre's highly trained mission briefing officers provides visi-

STS-1 launch/entry suit on display in the 'astronaut gallery'.

Houston

BY KEITH T. WILSON
Lanark, Scotland



tors with up-to-the-minute information on NASA space events.

Space Center Theatre
An exhibit of spacesuits from Mercury to the Shuttle is located in the astronaut gallery which is the pre-show area for the theatre. Other flight suits and clothing are also on show including Dick Covey's Hawaiian shirt worn on STS-26. The 500 seat theatre itself has a five-story tall screen capable of showing IMAX space films. Currently, the large-format film produced for Space Center Houston entitled 'To be an Astronaut' is being shown. This twenty-five minute feature film gives a behind-the-scenes look at astronaut training.

The Feel of Space
Space Center Houston's hands-on interactive area features an array of challenging activities. Computer simulators allow visitors to land the shuttle orbiter or retrieve a satellite. This area has no less than six landing simulators, six orbital rendezvous simulators and twelve shuttle orientation interactive trainers! The 'living in space' exhibit is a 40 foot mock-up of a space station module which simulates what life could be like for astronauts aboard the international space station in the late 1990's. A mission briefing officer gives a fifteen minute demonstration and volunteers from the audience get the chance to try out crew sleeping restraints and to prepare a space meal.

'The feel of space' also has a variety of space helmets which visitors can try on. A Manned Maneuvering Unit (MMU) trainer is located at the entrance to this venue. It is an air-bearing device and has been designed to demonstrate that working in open space is not without its problems. The MMU has to be positioned under a satellite where a number of tasks are carried out. However both time and fuel are limited!

JSC Tram Tour
Space Center Houston's sixth and final theme area is not actually located in the centre. It is the NASA JSC tram tour which allows visitors to travel to nearby JSC to witness several of the NASA centre's facilities. Visitors have the choice of two tours, one lasting forty-five minutes which takes in the Mission Control Center and another lasting seventy-five minutes which takes in the Space Environment Simulation Laboratory, the Mock-Up and Integration Laboratory and the Weightless Environment Training Facility. Both tours visit the rocket park which houses retired flight hardware. Special visitor observation points have been constructed for Space Center Houston visitors along the routes.

Space Center Houston has all the usual amenities including buffet and full-service restaurants, a 'spacetrader' retail shop, 'picture yourself' photographic souvenirs and an information desk. The centre is open 9am-7pm during summer and the 1993-94 charges are $9.95 for adults and $5.95 for children under twelve. If you are in the Houston area it is well worth a visit.

Rescue and Return of Astronauts

Principal International Instruments

On Monday 16 March, 1992, *The Times* Newspaper in London carried a story headed "Mir Man to be rescued at last" [1]. It told how three cosmonauts were to be launched the following day to link up with the orbiting Mir Space Station and in the process return to Earth another cosmonaut who, due to the turmoil created by the collapse of the former Soviet Union, had spent an unforeseen extra six months in orbit [2]. This incident, although somewhat unique, illustrates the perilous nature of space flight and dramatically highlights the dangers facing space explorers. Space is an unforgiving and hostile environment. Mankind's attempts at conquering it so far have not been without tragedy. At least fourteen human lives have been lost to date [3].

BY JEFFREY S. BRONSTEIN
Tasmania, Australia

Introduction

It is against a background of the hazards of manned space flight that the international community, predominantly through the United Nations, has reached agreement on a set of assistance mechanisms for space explorers. The efforts of the international community to date have resulted in two principal instruments dealing with astronaut assistance.

The 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (The Outer Space Treaty) [4] and The 1968 Agreement on the Rescue of Astronauts, The Return of Astronauts and The Return of Objects Launched into Outer Space (The Astronauts Agreement) [5]. The thrust of this paper will be to focus on those aspects of the above instruments which deal directly with the rescue and return of astronauts.

The Outer Space Treaty

Article V of the Treaty is the principal provision dealing with astronaut rescue. The article reflects and is an amalgam of two proposals submitted to the First Committee of the U.N. General Assembly when it was considering its Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space [6].

The first proposal was presented by the United States on 12 December 1962 and the second by the Soviet Union on 16 April 1963. Article V consists of two paragraphs and reads:

> "States Parties to the Treaty shall regard astronauts as envoys of mankind in outer space and shall render to them all possible assistance in the event of accident, distress, or emergency landing on the territory of another State Party or on the high seas. When astronauts make such a landing, they shall be safely and promptly returned to the State of registry of their space vehicle.
>
> In carrying on activities in outer space and on celestial bodies, the astronauts of one State Party shall render all possible assistance to the astronauts of other States Parties. States Parties to the Treaty shall immediately inform the other States Parties to the Treaty or the Secretary-General of the United Nations of any phenomena they discover in outer space, including the Moon and other celestial bodies, which could constitute a danger to the life or health of astronauts". [7].

In effect Article V of the Treaty "reaffirms and amplifies" the principles contained in the Declaration of 1963 [8]. The only addition to the 1963 Declaration was the insertion of a mutual assistance clause i.e. other astronauts when in outer space are required to "render all possible assistance to the astronauts of other States Parties" [9].

Interestingly, the Article only uses the term "astronauts" which, it has been submitted, only refers to those personnel who are actively engaged in the piloting of the spacecraft or who are otherwise required to be on board to fulfill some essential task relating to the operation of the spacecraft itself [10]. Hence "paying passengers" which have become more common during the latter half of the 1980's, as certain space faring nations attempt to recoup some of the enormous cost of space operations, may well be excluded from the scope of the Treaty [11]. More will be said on this aspect later in this article.

The principles enumerated in Article V are general ones, that is to say, they do not constitute firm rules of conduct which would give a State Party a clear and unequivocal cause of action to follow, should one of the "events" described in the Treaty occur.

For example, what does "all possible assistance" mean in the context of paragraphs 1 and 2. Noting that the provisions of Article V have never been called into practice and therefore actual definitions are not possible, some theoretical definitions have however been suggested.

These include: (A State Party in rendering assistance should employ) "every means at its disposal, including electronic and optical equipment, means of communication and rescue facilities of different kind" [12]; "within the limits of the means at its disposal" [13] and "action within the limits of the facilities at the Contracting Parties' disposal." [14].

Given the generalised nature of the assistance provisions of the Outer Space Treaty and the attendant uncertainty, it was not difficult to understand why the space powers moved to put into place a more comprehensive instrument specifically dealing with astronaut rescue. Indeed, during the resolution on the acceptance of the Outer Space Treaty, the General Assembly requested the Committee on the Peaceful Uses of Outer Space (COPOUS) to "continue its work on the elaboration of.....an agreement on assistance to and return of astronauts and space vehicles." [15].

The Astronauts Agreements

Work on a specific agreement had in fact been undertaken by the Legal Sub Committee of COPOUS between 1962 and 1966. Work was slow with many drafts being considered, amended and rejected during this period. The Soviet Union, for example, submitted drafts dealing only with rescue of astronauts whereas the US and Australian - Canadian documents also covered the return of astronauts and objects. It has been suggested that it was the occurrence of two serious accidents in 1967 [16] which spurred on the space powers to finally reach an agreement [17]. However, others have stated that it was the rapid reversal of position of the Soviet Delegation on 13 September 1967 which facilitated the unanimous endorsement of the Treaty by the General Assembly on 19 December 1967 [18].

Although the agreement itself is comprised of some ten articles, only four deal with the substance of rescue and return. These are articles one to four. Broadly speaking, the Astronauts Agreement must be considered as a convention which was intended as an addition to the principles of the Outer Space Treaty with more precise and extensive regulations [19].

These four articles of the Astronauts Agreement will now be dealt with in turn.

Article One

Article one is the notification provi-

sion and it advances the principles merely implied by Article Five of the Outer Space Treaty by expressly requiring notification to the launching authority i.e. a State or an International Organisation such as the European Space Agency as well as the Secretary-General of the United Nations, should a State Party learn of the personnel of a spacecraft suffering distress or making an emergency landing anywhere on earth. In addition, this article extends the duty to notify situations which have occurred in Outer Space or even on Celestial bodies.

Article one speaks of "personnel" not astronauts. Whether this would cover passengers is debatable. Morally, the answer must be in the affirmative, to not include passengers would lead to plainly absurd situations whereby the astronauts would be safely and immediately returned to their country of origin or that country's representatives, but their passengers would be left to fend for themselves! Notwithstanding the bizarre result, a strict interpretation would suggest that the provisions of the agreement would not apply to passengers [20].

Article one in essence underpins all the later provisions of that Agreement in that it requires State Parties to "make it known" that an incident of the type described has occurred, thereby facilitating a focusing of some rescue attempt. In addition the article is framed by the use of words such as "immediately" and "without delay" thereby emphasising the need and attempting to remove any ambiguity concerning the timeliness of making an announcement of an incident in the terms prescribed [21]. It underpins the humanitarian nature of the Agreement in this regard.

Article Two

Article two attempts to establish the degree of aid which State Parties must render to astronauts who, due to accident, distress or unintended landing, have come to rest in the State Party's territory, including its territorial waters. A State Party must also inform the Secretary-General of the United Nations and the launching authority of what steps it is taking to rescue the astronauts. The principal issue surrounding an analysis of Article two is the "degree of assistance" required by a State Party. The article requires "all possible steps" to be taken. It is submitted that the words "all possible steps" require a State Party "to ensure at least in theory, that the maximum possible rescue effort be made." [22].

Whether this would require a State Party to expend enormous sums of money and exhaust all of its search and rescue forces to the point of collapse will, it is submitted, come down to cases; that is a State Party will do what it can within prudent and practical limits to give effect to the provisions of the Agreement and no more. Thus, given an emergency which has occurred in one part of its territory involving loss of life to its own citizens, a State Party will not be "expected" to totally redirect its limited resources to a search for astronauts who have landed in another remote part.

Article two also extends the provision of the Outer Space Treaty by contemplating assistance by the launching authority in the rescue operation where such assistance "would help to effect a prompt rescue or would contribute substantially to the effectiveness of search and rescue operations ...." [23].

Article V of the Outer Space Treaty only provided for search and rescue operations by the state in whose territory the astronaut has landed. If a launching authority decides to render assistance, and if that assistance is accepted by the State in whose territory the astronaut has landed [24] then the territorial party would exercise direction and control over the search and rescue operation with both parties cooperating to the fullest extent possible.

Article Three

Article Three is a "high seas" provision and also seeks to cover situations where astronauts have alighted "in any other place not under the jurisdiction of any State." Unlike Article two, Article three only requires "Contracting Parties" to render aid "which are in a position to do so" and only "if necessary" to cooperate with rescue operations. Thus, smaller States and those with limited resources have an "out" legally in such situations, although morally it would still be obliged to render all technical assistance it could to save the lives of the astronauts [25].

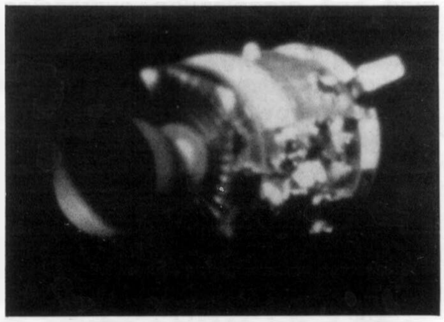
Article three also applies to Celestial bodies such as the Moon. However, in such circumstances the provisions of The 1979 Agreement Governing the Activities of States On The Moon and Other Celestial Bodies would probably take precedence as they are more precise [26]. Should an incident arise while the astronauts are in space the astronauts would not be covered by Article three as they would not have "alighted" but they would still have protection by virtue of Article V of the Outer Space Treaty [27].

Article Four

Article Four requires unconditionally a State Party to return the personnel of a spacecraft whose landing on the territory of a Contracting Party is unintended or is due to accident, distress or emergency. Thus even military personnel, providing that in fact they did land unintentionally, would be returned on humanitarian grounds.

Astronauts need only be returned to

The Apollo 13 astronauts James A. Lovell, Jr., Thomas K. Mattingly, II and Fred W. Haise, Jr., who made a hazardous return to Earth after an explosion in an oxygen tank severely damaged their Service Module in April 1970. NASA



The severely damaged Apollo 13 Service Module photographed from the Command Module just after separation from it prior to Earth reentry. An entire panel of the Service Module was blown away and caused the three crewman to use the Lunar Module as a "lifeboat". NASA

the "representatives of the launching authority" i.e. at the launching authority's embassy or diplomatic mission. Some writers have suggested that Article Four is so widely drafted that even if an astronaut had made a claim for political asylum, the territorial party would have to hand him over to the launching authority [28]. Others have relied on Article 14 of the Universal Declaration of Human Rights to argue that an asylum claim should prevail and in support suggest that granting an asylum claim pursuant to a jus cogens would override any divergent provision in a treaty [29]. The matter is clearly not settled.

Conclusion

The degree of "popularity" or otherwise of the Outer Space Treaty and The Astronauts Agreement is evidenced by the relatively few nations which have ratified them [30]. While the humanitarian aspects of both instruments, i.e. saving astronauts' lives should appeal to all nations, the reality is that many provisions of the instruments really only benefit nations with active space programmes [31].

While the instruments would not legally bind any third State [32] nor could be implied as binding in the sense that the provisions have the character of customary international law, [33] any third state which through its inactivity was in clear breach of the

humanitarian aspects of both instruments would be harshly judged by the international community as the instruments at the very least bring into existence some moral yardstick.

As with all international laws the astronaut instruments are a compromise and accordingly they contain a number of areas which require further development. These include some provision for the resolution of disputes, establishing clear conditions for requesting space rescues, the reimbursement of expenses for rescue operations, clarification of the status of astronauts as envoys of mankind, the right of asylum and the establishment of an international space rescue fund and organisation overseeing space rescues [34].

Notwithstanding the "shortcomings" of the above instruments, they do at least provide an international framework to facilitate the rescue of astronauts and their formulation

> " ..... bears witness to the fact that the United Nations can make a real contribution to extending the rule of law to new areas and to insuring the positive and peaceful ordering of man's efforts in science and the building of a better world." [35].

Bibliography

E.R.C. van Bogaert, *Aspects of Space Law*, Klewer, 1986.

R. Cargill Hall, Rescue and Return of Astronauts on Earth and in Outer Space, *American Journal of International Law*, **Vol. 63**, 1969.

Bin Cheng, The 1968 Astronauts Agreement of How Not to Make a Treaty, *The Year Book of World Affairs*, 1969.

Paul G. Dembling and Daniel M. Arons, *The Treaty on Rescue and Return Astronauts and Space Objects*, **Vol. 9**, William and Mary Law Review, 1969.

J.E.S. Fawcett, *International Law and the Uses of Outer Space*, Manchester University Press, 1968.

C.W. Jenks, *Space Law*, 1965.

Manfred Lachs, *The Law of Outer Space - An Experience in Contemporary Law Making*, Sijthoff Leiden, 1972.

Nicolas Mateesco Matte, *Aerospace Law*, Sweet and Maxwell, 1969.

McDougall, Laswell & Vlasic, *Law and Public Order in Space*, Yale University Press, 1963.

G.C. Reisnen, *The Pollution of Outer Space, In Particular of the Geostationary Orbit*, Martinus Nishoff Publications, 1988.

Damodar Wadegaonkar, *The Orbit of Space Law*, Stevens and Sons, 1984.

References

1. *The Times*, 16 March, 1992, p.14.
2. The Cosmonaut was Sergei Krikalyov and he returned safely to Earth on 26 March, 1992.
3. R. Chaffee, E. White, V. Grissom (USA) (1967); V. Komarov (USSR) (1967); G. Dobrovolsky, V. Patasayev, V. Volkov (USSR)(1971); R. Scobee, M. Smith, J. Resnik, R. McNair, E. Onizuka, G. Jarvis, C. McAuliffe (USA) (1986).
4. Adopted 19 December, 1966 U.N. Resolution 2222 (xxi), Entered into force 10 October, 1967.
5. Entered into force 3 December, 1968.
6. General Assembly Resolution 1962 (xviii) 13 December, 1963
7. Article V of The Outer Space Treaty.
8. M. Lachs, *The Law of Outer Space*, Sijthoff Leiden, 1972, p.88.
9. N.M. Matte, *Aerospace Law*, Sweet and Maxwell, London, 1969, p.326.
10. E.R.C. van Bogaert, *Aspects of Space Law*, Klewer, 1986, p.100.
11. *Ibid*, p.101.
12. M. Lachs, *Op Cit*, p.89.
13. *Ibid*, p.89.
14. *Ibid*, p.89.
15. P.G. Dembling and D.M. Arons, *The Treaty on Rescue and Return of Astronauts and Space Objects*, *Vol. 9*, William and Mary Law Review, (1969), p.630.
16. The deaths of astronauts Chaffee, White and Grissom of the US and cosmonaut Komonov of the USSR.
17. B. Cheng, The 1968 Astronauts Agreement, *The Year Book of World Affairs*, 1969, p.199.
18. P.G. Dembling and D.M. Arons, *Op Cit*, p.641.
19. E.R.C. van Bogaert, *Op Cit*, p.100.
20. *Ibid*, p.101.
21. P.G. Dembling and D.M. Arons, *Op Cit*, p.644.
22. *Ibid*, p.646.
23. *Op Cit*, p.647.
24. See the statement by Herbert Reis, US representative on COPOUS, 14 December, 1967 who said that "in the unlikely event that (the two States disagree over whether the launching authority should send in its equipment and personnel) they do not agree, the territorial party would of course have the final say in this matter."
25. P.H. Houben, *A New Chapter of Space Law: The Agreement on the Rescue and Return of Astronauts and Space Objects*, NILR, 1968, p.129
26. Article Twelve, Adopted by General Assembly Resolution 34/68 dated 5 December, 1979
27. P.G. Dembling and D.M. Arons, *Op Cit*, p.650.
28. *Ibid*, p.653.
29. M.G. Marcoff, *Studies in Space Law*; Its Challenges and Prospects, 1977, p.98.
30. As at 1990 less than 100 nations have ratified the instruments.
31. P.G. Dembling and D.M. Arons, *Op Cit*, p.661.
32. To third States a Convention is a res inter alias acta per the case of German Interests in Polish Upper Silesia, PCIJ, Series A, No. 7, 78
33. E.R.C. van Bogaert, *Op Cit*, p.106.
34. *Ibid*, p.115.
35. Statement of US Ambassador Goldberg commenting on the Astronaut Agreements, made to the United Nations General Assembly, 19 December 1967.

Return to the Moon

Sir, I find myself at odds with the views expressed by E. Philpott in ***Spaceflight***, January 1994, p.31. The current state of NASA is due largely to the attitude of the US Government. Despite two major Commissions in the last eight years both agreeing in broad terms on the way ahead, the US Government has ignored both reports and refused NASA the funding it richly deserves.

I would therefore suggest that the last thing you should do is privatise the US Space Program (Is there a Private Concern big enough to take over that kind of Research Funding?). Instead, have them review a long term programme every, say, five years with the option of coming in if actual costs rise above 130% of planned costs in any one year.

With that behind you, then restart the cancelled Space Exploration Initiative with the above multi-year funding and America will be back on the Moon to stay before you know it, with Mars just around the corner.

M.M. HUGHES FBIS
Northants, UK

Interplanetary Vision

Sir, What a depressing view of Mankind's future is painted by Michael Roe's letter in ***Spaceflight***, January 1994, p.32! Mr Roe fails to grasp the essential resilience and adaptability that is ingrained in our species, a trait that cries out from the pages of history and will be mankind's future salvation.

As a teenager I listened with fascination to my grandfather's stories of the first motor cars, and of my home town's first motoring accident. The world of less than a lifetime ago was a radically different place from the one in which we now live and the pace of change is rapidly accelerating, scarcely held back by recurring economic recession.

The town I live in is so changed from its predecessor of the 1960s as to be virtually unrecognisable, indeed the towering monument of its cathedral is almost the only unchanged thing. Every time I walk through the cathedral precincts I try to grasp the ideals of those men who worked on the huge building all their lives but died before it was even half finished. I come to the conclusion that there was a time when people were prepared to work towards a grand, even unimaginable, end and to invest precious resources in it with little hope of earthly reward.

Perhaps the grand design is something that our capitalist society has deprived us of, since it is of little short term economic benefit. Despite this it remains alive in the writings found in ***JBIS*** and ***Spaceflight*** on the Colonisation of the Solar System. Such ventures are the cathedrals of today but are outside the vision of politicians who see only four or five years hence. It can be argued that this blinkered political vision is the thing that will vanish in the future.

As the challenges around us grow exponentially to threaten civilisation, the political establishment must change to survive and human resilience will see that it does. The world of the future will know far more starvation and hardship, but paradoxically it will also have more material wealth and prosperity. The challenge for the free world is to nurture democracy and see that, against the odds, it continues to flourish. The challenge for all of ***Spaceflight's*** readers is to put the vision of mankind's interplanetary future firmly on the political agenda as the world economy grows, and to present realistically the phenomenal benefits that it will inevitably bring to all mankind.

The very nature of humanity will turn correspondence such as Mr Roe's into humorous reading on another world in a hundred years time, a world populated by many thousands of optimistic and ambitious people.

JOHN PREWER FBIS
Peterborough, Cambridgeshire

Sir, In his correspondence to ***Spaceflight***, Michael Roe displays an astonishing lack of imagination. He appears to accept the tenant that civilisation, as we know it, is doomed. But the whole point of space exploration is to avoid such a catastrophe and terraforming would provide one of the best such opportunities.

VINCENT BARITSCH
London SW17

Soviet Manned Lunar Mission

Sir, I am ever again fascinated by Korolev's daring manned lunar landing and return attempts (***Spaceflight***, December 1993, p.410).

In my humble opinion the inadequate N1 launch vehicle made for very tight and risky mission planning indeed. Its launch thrust was 4620 t and its LEO payload was 95 t compared with Saturn 5's 3400 t and a payload of 120 t. The escape payloads of ~44 t for Saturn 5 compared with perhaps 30 t for N1.

The fuel cells "Volna" mentioned on p.411 seem to be without fuel. The total system mass that I estimate for 1.5 kW, 500 hours (why so long?) would be around 560 kg.

I would welcome a complete mission description for Korolev's "Apollowitch" with full masses and performance figures. Any volunteers?

Prof Dr-Ing H.O. RUPPE
Munich, Germany

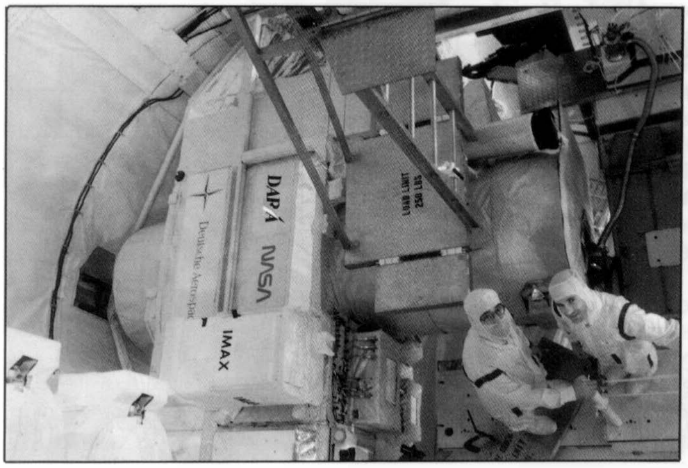
Animals in Space

Sir, Concerning the article in ***Spaceflight*** (October 1993, p.334), France, not China, is the third country to launch animals into space. It did so starting in 1962, with Veronique sounding rockets launched carrying mice from Hammaguir in Algeria. In 1967, they launched a female monkey in a suborbital flight and returned her safely. A cat may also have been launched in the early sixties and returned safely.

HENRY MATTHEWS
Lebanon

STS-51 Payload

Sir, I write to point out a small error in a caption on page 424 of the December 1993 issue of ***Spaceflight***. It says that the centre picture shows both ORFEUS-SPAS and ACTS-TOS, whereas, in fact, the picture only shows the ACTS-TOS payload.



I enclose one of my own pictures of ORFEUS-SPAS taken during routine servicing of the University of California, Berkeley (UCB) payload inside the ORFEUS telescope. The photographer, Dr Jerry Edelstein, was standing on the top platform of the payload clean room in the rotating service structure on pad 39B. The picture was taken before the first launch attempt on July 17.

I am on the left and William Donakowski, the UCB chief mechanical engineer, is on the right. The catwalk (labelled with "Load Limit 250 lbs") partly obscures an otherwise nice view of the ORFEUS-SPAS satellite inside of Discovery's payload bay. The flexible tube attached to the front of the ORFEUS telescope is part of the equipment used for the servicing that is routinely required before launch of this type of payload.

To the left is the ventral side of the payload bay (forming a vertical wall since Discovery is erected for launch). In the lower left are the two Get-Away-Special "GAS cans" of the LDCE experiment.

WILL MARCHANT FBIS
California, USA

Ed: *Thank you for the correction. A picture of the ORFEUS-SPAS payload appeared in* ***Spaceflight****, September 1993, p.304.*

China's Space Experiment

Sir, The data discussed in the article by Zhu Yilin, "Space Microgravity Scientific Experiments in China" (***Spaceflight***, October 1993, p.334) requires comment. I quote: "When recovered, space-orbited seeds were grown on Earth and showed remarkable variations compared with terrestrial samples" - and various extraordinary increases in size and growth rate, etc were then given. Changes in yeasts and bacteria were also reported.

To a member of the public this may seem all well and good - after all has not the "here be dragons" brigade often told of people, plants and animals coming back grossly deformed after a trip "up there" *via* popular films and sci-fi (for instance, 'The Quatermass Experiment')? Moreover, such imagined deformities and mutations have often taken the form of giantism - giant fish, babies, people - whatever. This is a recurring theme in our culture - look at the Cyclops, or David and Goliath.

However, that the environment of space could have seemingly produced this one type of effect - i.e. increased vigour and size of plants, bacteria, yeasts etc is *very unlikely* in the light of various other Space Life Science studies. For instance, fly larvae embryos suffer terribly in space [1], rarely developing to adulthood and suffering all sort of gross deformities. This is currently attributed to cosmic radiation rather more than to zero gravity.

These deformities are what one would expect; *a mutation is NEARLY ALWAYS disadvantageous, and often fatal*. The Genes and DNA of a given organism have evolved over millions of years and are the way they are for a purpose. If radiation etc changes them then the result is almost always bad. (That it may, very rarely, be a change for the better is the basis of Evolution). Yet in the Chinese experiments, after only a few days in space, these tremendously healthy plants have appeared!

That growth should be affected is also amazing. Genetically, physical growth is a complex concept, requiring the function of many genes - you do not inherit it in "steps" as you do with eye colour or blood groups which are based on only a few genes. Apparently **all** these different growth genes in the Chinese plants have been mutated by the cosmic rays in an identical manner so as to give increased growth!

The final piece of evidence that something is wrong comes from the NASA LDEF experiment, which was in orbit for six years between 1984 and 1990 - far longer than the Chinese Returnable Platforms. Among other things, this carried 14.5 million seeds of 106 different species and they received, through cosmic rays, five thousand times what the equivalent terrestrial radiation dose would have been over the six years of flight. And yet the seeds germinated well, and *hardly any mutations at all of any type whatsoever were reported*. To quote one of the LDEF project scientists [2]: "Space seems to be a surprisingly benign environment for seeds".

What then was causing the giant plants, etc seen by the Chinese? The results were simply examples of the natural variations within the plant and microbe populations. For instance, most people are between five and six feet tall in adulthood, but there are very occasional four or seven footers. The very tall and the very small people are simply occasional, random "sports".

In this case, someone has put all the "seven footers" - i.e. the naturally tall plants and naturally more virulent microbes - to one side and made a big song and dance about it. It was even said that one of the strains of yeast might revolutionise brewing, to which a cynic might reply that a microbiologist might find more promising candidates at the back of his throat, or in a bakers.

I am in no way directly criticising the Chinese Life Scientists who ran these missions. I know nothing of their techniques and am in no way qualified to comment anyway. I would, however, predict that a full analysis of the results might well show them to be very mundane overall.

OLIVER de PEYER
Oxford, UK

References

1. Bucker, *et al*, "Biorack on Spacelab D1", ESA, pp.135-145 and other articles in the same paper.
2. National Geographic, Vol. 180, No. 5, p.119, November 1991.

Comments Offered

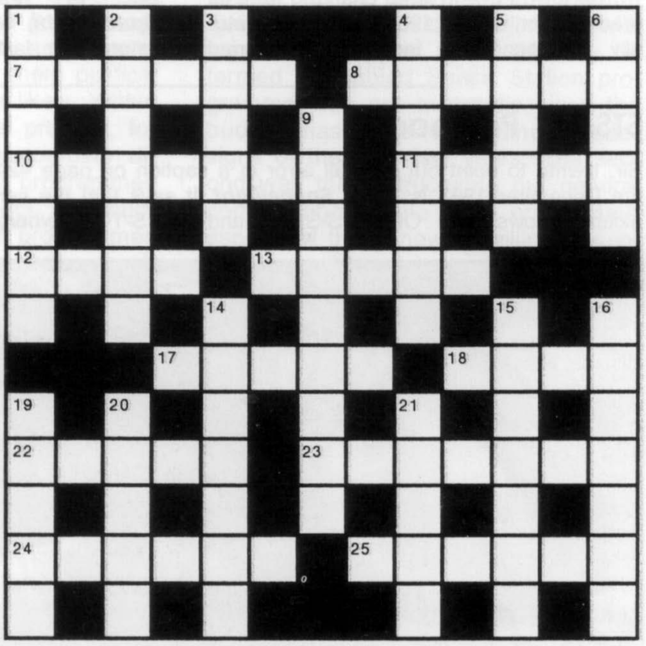
Sir, 1. In Satellite Digest - 259 (December, 1993, p.430) the UFO-2 weight is given as 2000 (?) kg. The press kit I got at the launch states that it weighed 6,269 lbs.

2. Ben Evans made a mis-statement about the Intelsat 6 rescue on p. 409 of his "Robots in Space" article (December 1993). The RMS did not grapple the satellite, the three spacewalking astronauts grabbed it by hand after the RMS grapple fixture could not be affixed to the satellite on two EVA attempts by Pierre Thuot.

JOEL W. POWELL
Space Information Canada
Alberta, Canada

Spaceflight Crossword

No. 6



ACROSS

7. European spacecraft deployed and retrieved during Shuttle missions
8. Manned spacecraft for twins?
10. Radar-radio dish that is the greatest
11. Once more
12. Research satellite that looked at the Earth's atmosphere
13. Issues
17. Designs
18. Search begins at a rearranged site
22. US-built Australian satellite
23. Pertaining to Herschel's 1781 discovery
24. Confine within limits as with satellite on mission STS-46
25. Capers that make a grating sound

DOWN

1. Space launcher that takes off with wings
2. Unpaid portion
3. Pungent
4. Leaves on a mission
5. Solar System satellite
6. Metallic sounding
9. Space traveller
14. Group together for ESA scientific mission to be launched in 1995
15. Microsatellite launched from Plesetzk
16. An early US spacecraft series
19. Pole in Antarctica
20. Specify
21. Walk resolutely to find part of China's space launcher

Solution will appear in the March issue.

Solution to Crossword No.5.

ACROSS: 1. Telecom; 5. Orbit; 8. Paddy; 9. Sitting; 10. Countdown; 12. Kit; 13. Lunacy; 14. Barren; 17. Cot; 18. Commander; 20. Turksat; 21. Years; 23. Sells; 24. Crew cut. **DOWN:** 1. Topic; 2. Led; 3. Cryptic; 4. Mascon; 5. Often; 6. Blinkered; 7. Tighten; 11. Unnatural; 13. Locates; 15. Analyse; 16. Emetic; 18. Costs; 19. Rosat; 22. Arc.

Space: The Way Ahead

Sir, I was most interested to read Mr R.P. Haviland's article on our next 50 years in space (*Spaceflight*, January 1994, p.2). I worked on the Blue Streak rocket in the fifties as a Junior Laboratory assistant at Hatfield.

The point which interested me was the second paragraph after the subheading "Space for Space" Programmes where he considers that the Space Shuttle was a mistake. I wonder that myself.

I watched the Channel 4 Equinox programme on the "Space Shuttle" and was particularly interested when a crew member suggested when passing the Saturn S4B, "It boggles the mind what would have happened if we had made small refinements in the performance of that rocket and what capability we would have now".

The problem with the development of very large space rocket boosters could be similar to that encountered in the ill-fated Russian N-1 space booster, the lack of adequate testing for political reasons.

I would favour a system that used aerodynamic lift as well as horizontal thrust to provide a reusable booster, such as the work of Dr Eugen Sanger a pioneer in both ram-jet and rocket propulsion in the thirties and forties.

P.D. SOMERVILLE
Sussex, UK

Space Songs

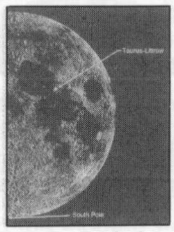
Sir, Here are the titles of two more space-related songs to add to the list contributed by *Spaceflight* readers: Barry Winslow's "The Smallest Astronaut", a sort of PS to the Royal Guardsmen's Snoopy series of novelty songs, and Reg Lindsay's "Armstrong" which sets the moonwalk against a backdrop of poverty, pollution and war on Earth.

The lyric of the latter can be taken either as decrying the Apollo programme as a misallocation of resources or holding it out as a ray of hope for a united humanity.

CHRISTOPHER RILEY
Victoria, Australia

The Editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

'Lunar Landing' Competition Winners



Lucky readers to whom books will shortly be dispatched are:

First Prize:

S.R. Jarratt — West Midlands, UK

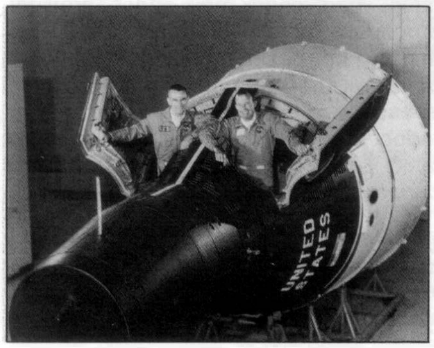
Consolation Prizes:

T. Ashton — Worcs, UK
J. Dunthorne — Lincs, UK
J.M. Govaerts — Luxembourg
W.G. Maxwell — Banffshire, UK

The correct answers are those arranged in the following order: Apollo 12, Apollo 16, Apollo 11, Luna 24, Luna 16, Apollo 15, Lunokhod 1, Apollo 14, Apollo 17, Luna 21.

'Crew Schedule' Competition

As well as the prime crew for a manned space mission, a backup crew is also trained and replaces the entire prime crew should any one of their number be unable to take part in the mission. If all goes to plan the backup crew is available to become the prime crew for the next mission: but if crew members fail their final fitness tests, crew assignments quickly take on a very different arrangement from that initially planned as our competition this month shows.



Prizes: The first correct entry to be opened after the closing date of 3 March 1994 will receive a copy of the recently published book:

A View of the Universe
by David Malin

For the next four correct entries to be opened there await Consolation Prizes of the book

Citizens of the Sky
by BIS Fellow Bob Parkinson

To Enter: Identify the two crew members who flew on each of the series of seven manned launches using the information provided.

Initial schedule

	Pilot	Engineer
Mission No. 1		
Prime	A	B
Backup	C	D
Mission No. 2		
Prime	C	D
Backup	E	F
Mission No. 3		
Prime	E	F
Backup	G	H
Mission No. 4		
Prime	G	H
Backup	I	J
Mission No. 5		
Prime	I	J
Backup	K	L
Mission No. 6		
Prime	K	L
Backup	M	N
Mission No. 7		
Prime	M	N
Backup	O	P

On Mission Nos. 1 and 5 the pilots failed their fitness tests and on Missions Nos. 3 and 7 the engineers did likewise.

If a prime crew member is unfit before any mission, the backup crew becomes the prime crew and is no longer the prime crew of the next mission.

An unfit crew member becomes backup for the next mission and prime for the mission after that. The backup whom he replaces becomes prime crew for the mission.

A fit crew member, who is forced to pull out of a mission due to an unfit companion, becomes a prime crew member of the next mission.

ENTRY FORM

	Pilot	Engineer
Mission No. 1	C	D
Mission No. 2	E	B
Mission No. 3	...	...
Mission No. 4	...	...
Mission No. 5	...	...
Mission No. 6	...	...
Mission No. 7	...	...

Title/Name ....

Address ....

....

....

Post to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, to arrive by first delivery on 3 March 1994.

Space Shuttle II

Next Generation Space Launch System

The United States must face imminent crucial decisions on its future role in space. Foremost among these is replacement of the Space Shuttle launch system. Challenges from foreign launch systems and prohibitive operational costs of the Space Shuttle make this decision imperative.

BY DON A. NELSON
Aerospace Technologist
Johnson Space Center, NASA

Two major factors must be considered in defining the next generation launch system: the requirements and the economy. The requirement goals should be to regain the commercial launch advantage, support military requirements, provide the science community with affordable access to space and establish a permanent US presence in space. American economic conditions will dictate that these required goals be achieved in long duration phases.

There are three options for the space launch system: the Spacelifter/National Launch System concept, a Single or Two-Stage-to-Orbit vehicle and an upgraded Space Shuttle system (Shuttle II). This article considers the third of these.

Current Shuttle launch costs of *half a billion dollars for each flight* are totally unacceptable. The launch complex can barely support 12 flights per year and the "marching armies" required to operate the Shuttle is a poor use of NASA's manpower. So why consider upgrading this terribly exorbitant launch system?

There have been some very significant technology advances since the design of the Space Shuttle in the 1960s. It is time to see if these technology advances and *different approaches to operations management* can help Shuttle reach the original goal of being an affordable space truck.

Shuttle Vehicle Configuration Changes

Delete the Manned Piloting Requirements

To construct an affordable next generation Space Shuttle we must accept not only that the days of pilots using "stick and rudder" on Earth launch vehicles are past but that the requirement for "Man Rated" is also. Future space vehicles must be designed to the maximum level of reliability as launch vehicles and payloads are too expensive to do otherwise.

By deleting piloting requirements *enormous* dollar and manpower savings can be realised.

Shuttle II flight crews will be required only for those missions whose payloads require crew interfaces. Safety can be increased by reducing the crew number to three or four and providing ejection seats.

Space Shuttle Configuration

The external configuration *must not* be significantly altered in order to avoid the costs of certifying new aerodynamic characteristics. The use of spoilers and canards may be advisable to reduce loads and increase stability, but not changing the Shuttle mould lines makes Shuttle II developments costs significantly less than any other launch system option.

Integrated Vehicle Health Management System

Computer technology has advanced to the state that an onboard management computer system can verify the status and also *control* all vehicle systems. Incorporation of an integrated health management system would result in a momentous improvement in ground operations costs. This is not new technology and has been proved extremely effective on modern aircraft. It is a "must have" requirement.

Space Shuttle Main Engine

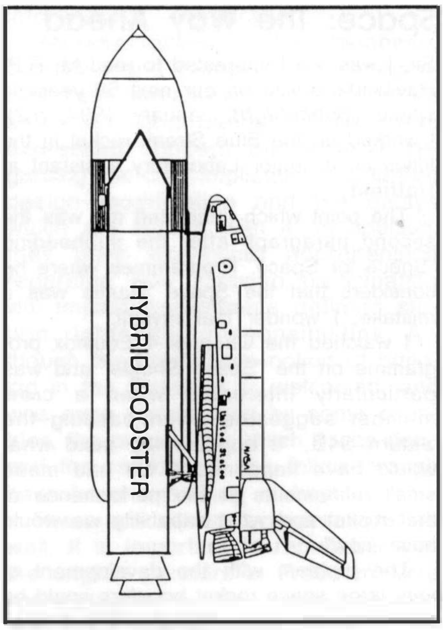
The engine will require extensive use of integrated health monitoring and single cast construction of large components. High pressure pumps must be incorporated that can be flown 50 times before overhaul. Rocketdyne has projected that an advanced engine can be turned around in 58 hours as compared to the current time of 160 hours.

Hybrid Rocket Booster System

An expendable liquid rocket booster cannot be justified because of the operational recovery costs. Solid boosters have been made obsolete by recent developments in hybrid booster technology. Hybrid boosters will enhance abort modes, have fewer critical failure modes, less environmental impact and give 15% greater performance than solid motors. Industry studies indicate recurring cost to be 40% less than the current solids. *This motor is mandatory for Shuttle II.*

External Tank

The $30 million cost for an external tank is exorbitant. The lightweight tank programme should be redefined



Space Shuttle II.

to explore ways to reduce the manufacturing costs. The requirements goals of Shuttle II will demand higher flight rates, permitting more than one manufacturing supplier. More manufacturers will encourage competition, which has always been the best way to reduce cost. NASA should develop a "ship, *load*, check and shoot" preflight procedure for the external tank. Tanks that did not pass the load check would penalise the manufacturer's profit. It is essential that external tank costs be reduced to less than $10 million per tank. *This is mandatory if the Shuttle II concept is to be an affordable system.*

Vehicle Flight Subsystems Restoration

Subsystems must be of a modular concept, designed for unconstrained replacement. The spare parts operation must be based on modular replacement of the subsystem. Modular replacement is required to reduce the time for replacing flight unacceptable components from days to hours. Modular replacement designs must consider launch pad and on-orbit replacement of failed equipment. A dedicated facility is required for space modules repair, checkout and storage.

Table 1: Roles and Missions for Space Shuttle II.

DOD Heavy Lift
Western Test Range Launches
Space Debris Retrieval
Commercial Payloads Delivery
Space Rescue
Propellant Tank Farm Delivery
Space Station Logistics
Mission Earth Support
Space Power Beam Platform Delivery
Deep Space Deploy
SEI Spacecraft Delivery
SEI Payload Return

Note: This paper does not represent an official NASA position but gives a composite of views from many different sources formulated into a concept for making an upgraded Space Shuttle an affordable option for the next generation space launch system. It is based on an edited version of an article recently published in *Aerospace America*.

Electrical Power Systems
Long life (10,000 hours) high amperage fuel cells are required to support the electrical actuators. Electrical actuators must be used to reduce the fire hazards and high maintenance costs.

Thermal Protective System
Tile maintenance has been a major cost item for Shuttle turnaround. The use of metallic tile, mechanical fasteners, carrier panels, carbon-carbon, rigid ceramic and other current technology would make installation and removal economical.

A "Software Czar" is mandatory to insure standard software subsystems interfaces. Shuttle II software would be 50% of the development cost and would require close monitoring.

Shuttle II Operations
Ground and flight operations at KSC must be centralised to reduce numbers of support personnel. The support personnel launch team members must be responsible for both preflight and flight operations if significant reduction in operations manpower costs are to be realised. Shuttle II's autonomous operation concept makes this requirement achievable. The provisions of the Government Corporation Control Act should be used to establish a government corporation for launch support. Payload operations must be separated from launch operations.

Future Upgrades
A major reason why the current Shuttle system is so expensive is that upgrades have been individually selected in a random process and serially applied to each vehicle, a process that is excessively expensive.

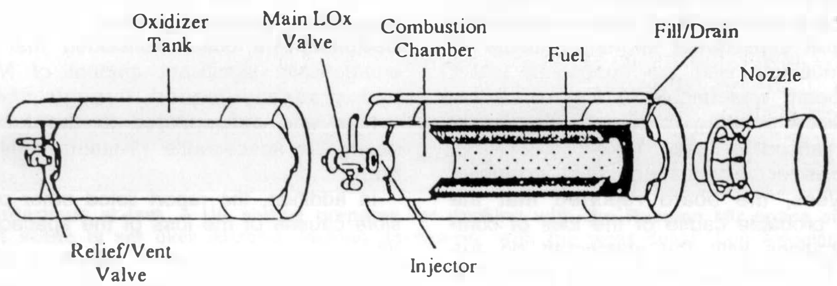
The next generation Shuttle system must adopt a policy of 10-year periodic block upgrades. A similar policy has been very successful for the Russian Soyuz system. The development and testing of the block upgrades must be done outside the operational launch flow and outside the organisation of the Shuttle operators.

Encapsulated Payloads
A "ship and shoot" policy for payloads must be adopted to reduce operations costs. Payload interfaces with the Shuttle must be reduced. Payload designers must "encapsulate" their requirements within the payload systems. NASA's current policy allows too many payload development and operations costs to be charged to Shuttle operations costs. The Shuttle II must be a launch system, not an on-orbit service platform.

Pre-Mission Planning
Shuttle pre-mission planning is based on an organisational structure that transfers products from one department to another. Even when the products are transferred electronically, the process is manpower intensive and laborious, e.g it currently takes over 475 days to develop the pre-mission products for each flight.

Hybrid Boosters

Hybrid motors are part solid rocket and part liquid. The liquid oxidizer (LOX) is pumped or pressure fed into the combustion chamber containing the solid fuel for ignition. The technique provides advantages of safe ground handling and motor shutdown after ignition. Imperfections in the fuel are not as critical as with solid fuel motors.



Flight planning design computer programs have been developed that incorporate common databases, total vehicle environment modelling and internal iteration processes. These flight design computer programs, incorporating sequential quadratic programming, have reduced the flight design from months to a few days and significantly reduced manpower requirements.

Ground Facilities
KSC ground facilities are in dire need of repair. Restorations of these facilities will require a major investment of NASA resources and must consider the requirements of the next generation launch system. Shuttle II autonomous operations and a hybrid booster system will significantly reduce the complexity of facilities.

Development and Operations Timeframes
Past launch system projects indicate the development time to be approximately seven years with an additional three years for flight tests. Operation lifetime should approach thirty years.

Launch Rate
A crystal ball forecast of US long range launch needs for payload in the 30,000 to 50,000 pounds range indicates a flight rate of 20 to 60 flights per year during the expected 30 years' lifetime of the next generation launch vehicle (commercial 10-16, military 4-10, Earth observations 2-4, space exploration 4-30). The launch rate will be a major factor in the development of the launch vehicle and support facilities (Table 1).

The Shuttle II concept defines a path for the development of the next generation of space transportation system. It dictates that planners should concentrate on space based systems and vehicles delivered and supported by Shuttle II.

Conclusions
Keeping the Shuttle external configuration makes Shuttle II the least expensive launch option to develop. Operations costs will be determined primarily by the recurring cost of hybrid boosters and external tanks, consolidating and centralising operations at KSC and deleting piloting requirements.

Autonomous operations with internal vehicle health management will significantly increase flight rate capability and reduce ground operations costs. These changes will free resources for a deep space initiative supported by the Shuttle II and create jobs for the excess Shuttle work force.

Bibliography
"Leadership and America's Future in Space", (Ride Report), August 1987.
"Toward a New Era in Space - Realigning Policies to New Realities", Report to President Bush by the National Academy of Sciences and National Academy of Engineering, December 1988.
"America on the Threshold - America's Space Exploration Initiative", (Stafford Report), May 1991.
"Advisory Committee on the future of the US Space Program", (Augustine Report), December 1990.
"Space Transportation Week - Space Transfer Vehicle", MSFC Quarterly Reviews - NAS8-37856,7., August 1991.
"Research and Technology Goals and Objectives for Integrated Vehicle health management", NASA Office of Aeronautics and Space Technology, October 1992.
"Access to Space - the Future of US Space Transportation Systems", Office of Technology Assessment, 1990.
"From Earth to Orbit - an Assessment of Transportation Options", National Research Council, 1992.
"Advanced Manned Launch System Study", NASA Langley, June 1992.
"An Operational Concept for the Development of the Nation's Next Generation Space Transportation System", White Paper, Don A. Nelson, NASA JSC, April 1992.

Mars Observer

The final report by the independent investigation board on the failure of the Mars Observer spacecraft has been delivered to NASA Administrator Daniel S. Goldin by Dr Timothy Coffey, Chairman of the board. The Mars Observer spacecraft fell silent just three days prior to entering orbit around Mars, following the pressurisation of the rocket thruster fuel tanks.

Because the telemetry transmitted from the Observer had been commanded off and subsequent efforts to locate or communicate with the spacecraft failed, the board was unable to find conclusive evidence pointing to a particular event that caused its loss.

However, after conducting extensive analyses, the board reported that the most probable cause of the loss of communications with the spacecraft on August 21, 1993 was the rupture of the fuel (monomethyl hydrazine, MMH) pressurisation side of the spacecraft's propulsion system, resulting in a pressurised leak of both helium gas and liquid MMH under the spacecraft's thermal blanket. The gas and liquid would most likely have leaked out from under the blanket in an unsymmetrical manner, resulting in a net spin rate. This high spin rate would cause the spacecraft to enter into the "contingency mode", which interrupted the stored command sequence and thus did not turn the transmitter on.

Additionally, this high spin rate precluded proper orientation of the solar arrays, resulting in discharge of the batteries. However, the spin effect may be academic, because the released MMH would likely attack and damage critical electrical circuits within the spacecraft.

Based on tests performed at the Jet Propulsion Laboratory (JPL) Pasadena, California, the board concluded that an energetically significant amount of NTO had gradually leaded through check valves and accumulated in the tubing during the spacecraft's 11-month flight to Mars.

In addition, the report listed other possible causes of the loss of the spacecraft as:

- failure of the electrical power system, due to a regulated power bus short circuit;
- NTO tank over-pressurisation and rupture due to pressurisation regulator failure;
- the accidental high-speed ejection of a NASA standard initiator from a pyro valve into the MMH tank or other spacecraft system.

Other concerns noted by the board included:

- a need to establish a policy to provide adequate telemetry data of all mission-critical events;
- the lack of post-assembly procedures for verifying the cleanliness and proper functioning of the propellant pressurisation system;
- a current lack of understanding of the differences between the characteristics of European Space Agency and NASA pyro-initiators;
- the potential for power bus short circuits, due to single component or insulation failure;
- the potential for command and data handling control systems to be disabled by single-part failure;
- the lack of fault protection external to the redundant crystal oscillator (RXO) should one of its two outputs fail;
- the absence of information, in the telemetry, on the actual state of the RXO's backup oscillator;
- deficiencies in systems engineering/flight rules;
- too much reliance placed on the heritage of spacecraft hardware, software and procedures for near-Earth missions, which were fundamentally different for the interplanetary Mars Observer mission; and
- the use of a firm fixed-price contract restricted the cost-effective and timely development of the unique and highly specialised Mars Observer Spacecraft.

Dr Coffey noted, "We were challenged to conduct an extraordinarily complex investigation in which we had no hard evidence to examine nor communications with the spacecraft. However, after an extensive analysis covering every facet of the mission, operations and hardware, I believe that we are justified in arriving at the conclusions we have. If our findings will help to ensure that future missions will not suffer a similar fate, we feel we will have achieved our purpose".

Europa 1 Rocket Found

SYDNEY - European rocket Europa 1 launched 27 years ago, but missing since shortly after take-off, was found in the Australian outback in August 1993.

Wreckage was found on the southeast edge of the Simpson Desert in South Australia during an aerial survey of an area 70 km (44 miles) north of Woomera.

Europa 1 was launched in 1966 from the Woomera rocket range by the European Launcher Development Organisation, precursor to the European Space Agency which then included Australia. It was 32 metres long when launched, weighed 107 tonnes and carried a dummy satellite. Two minutes after lift-off it went out of control and disappeared off radar screens.

Russia Signs Protocol for New Guinea Spaceport

SYDNEY - Russian space officials have signed a protocol with an Australian company for a planned billion-dollar spaceport off the Pacific island of New Guinea.

The 12-member delegation visited Emirau and Manus islands, both Papua New Guinea (PNG) territories, where Space Transportation Systems Ltd (STS) is hoping to build the world's first commercial rocket launching site. Both sites were endorsed as technically suitable to provide a Proton launch facility. STS, a private company owned by Australian and Russian investors would have exclusive rights to use the Russian space agency Glavkosmos' Proton rocket outside Russia to launch commercial payloads into space. Proton rockets now lift payloads of 2.2 tonnes into space from Baikonur. PNG's proximity to the equator would enable the rocket to lift 4.6 tonnes.

In May the PNG government granted STS approval in principle to build an Australian $1 billion (US$667 million) commercial space launch facility on one of the islands. STS plans to begin construction in 1996. The company hopes to be launching satellites into orbit from 1998.

Upgrades planned for the last stage of the Proton rocket are expected to allow it to put a total of seven tonnes into orbit. The delegation, which returned to Moscow from Brisbane, included engineers, economists and scientists from Russia's Department of Space Rocket Technology, the State Space Science Production Centre and Glavkosmos.

Outlook Bright for Weather Forecasts

In-Orbit Acceptance-Testing Precedes Meteosat-6 Handover

Following its successful Ariane launch on 20 November 1993, (*Spaceflight*, January 1994, p.35), the Meteosat-6 satellite acquired its first weather images nine days later. The next step had to await the cooling down of the radiometer over the next two days to enable acquisition of images in the infrared and water vapour channels to begin.

During quality analysis of these latter images, an anomaly was detected in the functioning of the radiometer, the reasons for which have been under investigation by experts from ESA and the firms involved. In-orbit acceptance testing has nevertheless continued in accordance with the original schedule, which leads to the transfer of ownership of the satellite from ESA to Eumetsat by the end of February 1994.

Meteosat 6 will be operational at 0° longitude. It was developed and will be operated by ESA on behalf of Eumetsat. As from the end of 1995, Eumetsat will take over operations of all Meteosat spacecraft from ESA.

Eumetsat currently intends to make Meteosat-6 the operational satellite replacing Meteosat-4, which will become the in-orbit back-up satellite. Meteosat-5, which has served as back-up so far, will then be moved westwards over the Americas. There it will take over from Meteosat-3, which has been on loan to the US weather service, NOAA, since 1991, until NASA's next-generation geostationary satellites are launched and become operational. After 5 years of service, Meteosat-3 has little propellant left for orbital manoeuvres, and needs to be replaced within a couple of months from now. During the 1994 hurricane season, Meteosat-5 is expected to play an important role in the detection and real-time tracking of these dangerous events.

Meteosat-6, which is now in orbit and Meteosat-7, which is to be launched at the end of 1995, will ensure continuity of vital weather data until the turn of the century. Meteosat spacecraft are manufactured by a consortium of European companies led by Aerospatiale of France under contract to ESA.

Remote Sensing by Microsatellite

More than 100 images world-wide have been collected by the Earth Imaging System cameras on-board the first Portuguese satellite, PoSAT-1, showing both regional weather patterns and details as fine as roads and bridges.

In comparison with traditional large remote sensing satellites, which typically cost over £200 million each, the PoSAT-1 microsatellite weighs only 50 kg and was built and launched in less than one year at a cost of only £1.2 million. It was launched by Ariane on 26 September 1993 (*Spaceflight*, November 1993, pp.374-375).

PoSAT-1 was built and launched within a collaborative programme in satellite technology established between the Centre for Satellite Engineering Research at the University of Surrey, UK and the PoSAT Consortium based in Lisbon, Portugal.

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Shuttle-Mir Rendezvous

NASA's first female shuttle pilot and a Russian cosmonaut have been assigned to a rendezvous with Russia's Mir space station in 1994. It will be the first space flight for Eileen Collins, an Air Force lieutenant colonel, who in 1990 became the first and only woman to be chosen by NASA as a shuttle pilot.

The six-person crew, also includes Vladimir Titov, who along with Musa Manarov spent 366 days in space in a flight that ended in December 1988, a world record. He will be the second Russian to fly on a US shuttle; the first will have been Sergei Krikalev on Mission STS-60.

The rendezvous between Discovery and Mir is scheduled for June 1994. Preliminary plans call for Discovery to fly within 400 to 1,000 feet of Mir and then fly around it in preparation of a shuttle docking planned for 1995.

Buran's Future

MOSCOW - The Buran shuttle programme, halted in June 1993 for lack of cash, should be restarted, according to the Russian Prime Minister Viktor Chernomyrdin. The multi-billion dollar Buran programme which was the pride of the Soviet Union flew only once before the money ran out. It is now languishing in a hangar at the Baikonur cosmodrome. Russia and Kazakhstan are in dispute over the Baikonur cosmodrome. Moscow wants to keep the base under the control of the armed forces while Kazakhstan is pressing for it to be opened up to attract foreign investment.

Egypt Satellite

CAIRO - Egypt is negotiating with foreign companies to finance launching its first communications satellite. The satellite, to be named Nilesat after the River Nile, will have a capacity of 24 television channels as well as radio circuits for telecommunications. Egypt is a member of the pan-Arab satellite group Arabsat and uses one of its channels to beam a television service to Arab, African and European countries.

Meteosat Weather Watch

The first European geostationary satellite, Meteosat-1, was launched on 23 November 1977.

European meteorological services have since been receiving images of the Earth taken at half-hourly intervals from an altitude of 36,800 km. The images cover Europe, Africa, the Atlantic, the Middle East and part of the CIS.

The first satellite was followed by four more, three of which are still operational:

- Meteosat-3, launched on 15 June 1988 and placed at 75° W, is used by the American meteorological services.
- Meteosat-4, launched on 6 March 1989, is used daily by national meteorological offices and provides pictures for the weather forecast broadcast on TV.
- Meteosat-5, launched on 2 March 1991, is kept as a back-up in case one of the other two satellites breaks down.

Meteosat-6 will take over from Meteosat-4 in February 1994.

Based on edited material from the EURISY Newsletter, October 1993. For further information on the Meteosat programme see ***Spaceflight***, October 1993, p.337.

Remittances by GIRO from Abroad

We have been advised by GIRO that a charge of £2.50 is now to be levied on all remittances from abroad.

Those remitting from abroad should, therefore, kindly note that the amount sent should be increased by this sum in order that the net remittance received by the Society is sufficient to clear the amount payable.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: All Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Admission is by ticket only. Members should apply in good time enclosing a sae. Subject to space being available each member may also apply for a ticket for one guest.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

2 February 1994 — 7 - 8.30 pm

Nuclear Electric Propulsion Space Test Programme

D.G. Fearn

The nuclear electric propulsion space test programme (NESTP) was conceived by SDIO, now BMDO, to examine the use of the Russian Topaz 2 nuclear reactor for powering a variety of electric thrusters. The aim of the mission is to employ these thrusters in the spiral orbit-raising role. The lecture will cover the reactor, the thrusters to be used, the spacecraft design, and the mission. Reference will also be made to possible interplanetary applications of this exciting new approach to spacecraft propulsion.

16 March 1994 — 7 - 8.30 pm

Picometers, Photons and Gravity Waves: The Uses of Interferometers for Space-Based Astronomy

W.I. McLaughlin

Modern technology now allows the light-management techniques of interferometry to be fully implemented in a space setting. Precision measurements of celestial positions can reveal both the architecture and the dynamics of celestial ensembles, and razor-sharp images can also be synthesized. In addition, the detection and analysis of gravity waves is feasible through interferometric methods. Techniques and proposed missions will be discussed.

1 June 1994 — 7 - 8.30 pm

The Microlight Solar Sail

C. Jack

The solar sail is a well established concept. Harnessing the pressure of sunlight, a spacecraft would have unlimited range. In principle, it could travel from Earth orbit to anywhere in the Solar System without using fuel.

However it is difficult to design a solar sail capable of carrying large payloads. Sunlight exerts less than one kilogram force per square kilometre. Deploying and controlling the large area of fabric necessary to convey a conventional spacecraft would be hard. This is why, despite the potential of the idea, no such craft has actually been launched.

Recent advances in microelectronics make possible a quite different concept: a tiny rigid sail just a few metres in diameter which could be controlled purely by electronics, without moving parts. The key components of the craft will be a tiny CCD camera developed at Edinburgh University which can act as both attitude sensor and data gathering device, high performance solar cells providing a few watts of power for control and communication, and a radio which uses the sail itself as a directional antenna. Several attitude control methods are feasible: for example, the net pressure sunlight exerts on a solar cell varies according to the power drawn, and this effect can be harnessed.

The craft will be highly manoeuvrable compared to a large sail, so capable of progress under its own power from a low initial orbit. It can thus be launched as a 'piggyback' payload at very moderate cost. It will nevertheless be capable of some ambitious missions, including in particular rendezvous with near-Earth asteroids. It could transmit back closeup pictures at a low bit rate, and might even be capable of sample return: entering the Earth's atmosphere, the sail acts as its own re-entry parachute, the temperature remaining moderate due to the small load per unit area.

There is active interest in the device at a number of British universities, and the current aim is to progress the project towards a hoped-for launch.

6 October 1994 — 7 - 8.30 pm

The First Manned Lunar Landing Spacecraft: Its Design, Manufacture, Ground Test and Mission

R. Fleisig

This paper uses the development, production, testing and flight of the first successful manned lunar landing spacecraft as a point for current studies of future spacecraft used for a return to the Moon. Described are the Saturn V launch vehicle and the Apollo spacecraft. Apollo trajectories are identified for each mission phase and lunar surface temperatures and other factors considered.

SYMPOSIA & CONFERENCES

4 June 1994 — 10-4.30 pm

Soviet Astronautics

Authors wishing to present papers should contact the Executive Secretary.
Advance Registration is necessary.
Registration: Forms are available from the Executive Secretary. Please enclose a sae.

23 June 1994 — 10-4.30 pm

Space Industrialisation as a Response to Global Threats

Authors wishing to present papers should contact the Executive Secretary.
Advance Registration is necessary.
Registration: Forms are available from the Executive Secretary. Please enclose a sae.

15th September 1994 — 10-4.30 pm

Space Transportation and Infrastructure

Authors wishing to present papers should contact the Executive Secretary.
Advance Registration is necessary.
Registration: Forms are available from the Executive Secretary. Please enclose a sae.

9-14 October 1994

45th IAF Congress "Space and Cooperation for Tomorrow's World"

The 45th Congress of the International Astronautical Federation will be held in Jerusalem, Israel, October 9-14, 1994. There are 98 technical sessions planned.

LIBRARY

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm.
Membership cards must be produced.

48 GUNTON DRIVE

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The International Magazine of Space and Astronautics

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Space Partners

Cosmonautics

Features

News & Events

Space Miscellany

Front Cover: **The STS-60 flight crew lines up on a high elevation platform at Launch Pad 39A having just completed the Terminal Countdown Demonstration Test, a dress rehearsal for the launch. From left to right: Mission Specialists Jan Davis, Sergei Krikalev and Ron Sega; Pilot Ken Reightler; Commander Charles Bolden; and Mission Specialist Franklin Chang-Diaz. The tip of the external tank of the Space Shuttle Discovery is visible behind them.** NASA

At Launch Pad 39A, STS-60 Mission Specialists Sergei Krikalev (left) and Franklin Chang-Diaz complete the final phase of the Terminal Countdown Demonstration Test, a dress rehearsal for launch. NASA

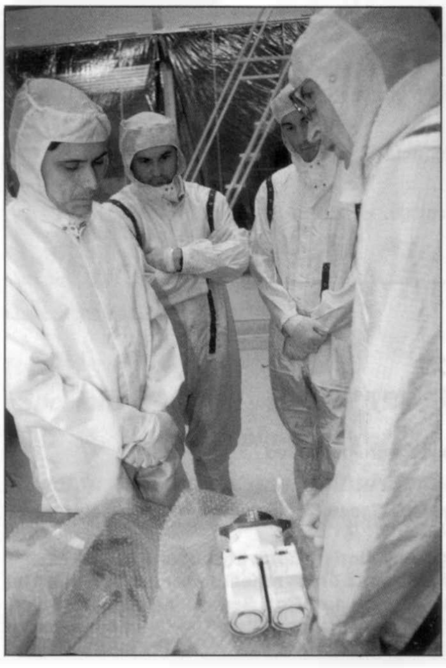
Russian Flies as STS-60 Crewmember

'Ultra-Vacuum Facility' not Released

Discovery was launched at 7:10 am EST on 3 February carrying on board the first Russian cosmonaut to fly on a US shuttle and opening up a new era of space cooperation. Joining the five American crewmembers was Sergei Krikalev, a Mir veteran of 463 days in space, who was wearing a Russian flag patch on the shoulder of his orange flight suit. The flight was the first joint US-Russian manned mission since the (then US-Soviet) 1975 Apollo-Soyuz docking and the first time ever in which astronauts and a cosmonaut had been launched in the same vehicle.

A special treat for all concerned was the experience of a trouble-free launch, particularly following the shuttle's recent history of launch delays and postponements. Yuri Koptev, head of the Russian space programme, praised the NASA launch team, 'It is remarkable that this launch has been on schedule, and everything is well and going all right. I hope that in our future cooperative projects, everything will be go as well and be right on schedule'.

In September 1993, (left to right) Franklin Chang-Diaz, back-up Mission Specialist Vladimir Titov, Sergei Kirkalev and senior project engineer Bill Creasy discuss the motor for the retention latch mechanism that will hold the Wake Shield Facility in the orbiter payload bay. NASA



Dan Goldin, NASA Administrator, took a bold look ahead saying, 'Today is the start of a whole new era. Instead of spending another 10 years of frustration making a lot of drawings and not getting anywhere, by the end of this century we're going to have an 800,000-pound station that we can take pride in with humans always in space from all over the world', adding, 'When the economies of our country and Russia straighten out, it's on to Mars'.

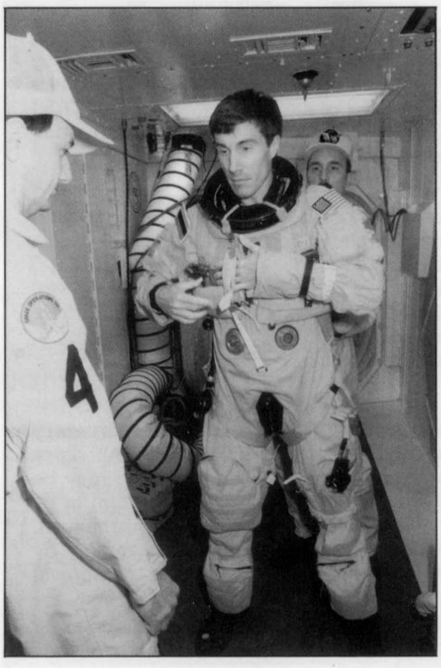
During the planned 8 days, 5 hours and 32 minutes of the mission, the astronauts had microgravity and life sciences experiments to oversee in the Spacehab laboratory module that is located in Discovery's cargo bay and connected to the crew cabin by a short tunnel. For Sergei Krikalev there were medical experiments in which to participate as well as operating the shuttle's 'arm' or Remote Manipulator System which was to be attached to the free flying part of the Wake Shield facility (WSF) for deployment and retrieval.

The WSF is a 12-foot diameter, stainless steel disk designed to generate an 'ultra-high vacuum' in its orbital wake in which to grow thin semiconductor films for next-generation advanced electronics. In operation, the WSF would stay 40 nautical miles behind the shuttle while growing thin films until Flight Day 5 when the shuttle would make a rendezvous and capture it using the mechanical arm.

Initial delays arose with the WSF deployment due to several factors, including radio interference between the radio transmitter on the Facility and the receiver on the payload bay carrier. However, difficulties with its attitude control system remained thereby shortening the time available for free flight and on 7 February the decision was taken not to proceed with the free flight part of the WSF's operations. A back-up plan was followed of growing the thin films with the WSF attached to the shuttle's arm, accepting a possible loss of purity compared with a free flying operation.

Although the main goal of the mission had not been accomplished, NASA officials pointed out that the Facility contained other useful experiments concerned with material processes in space and that the mission still had much to offer payload experimenters in the way of new results.

Sergei Krikalev participates in the Terminal Countdown Demonstration Test. NASA



Shuttle Part in Landfill

A $300,000 part for the space shuttle Discovery was found discarded in a landfill in November 1993 but was retrieved and installed on the orbiter. NASA said a panel that goes on the leading edge of one of the shuttle's wings was at the landfill for only four hours before it was discovered. A crate containing the panel was inadvertently taken to the landfill after an area of the Kennedy Space Center was cleared to prepare for an open house. The landfill is no longer accepting unopened crates.

Russian Role in Australian Spaceport Proposals

A project for launching rockets from Australia is the Cape York Commercial Spaceport venture which was initiated in 1987. Its aim was, and still is, to build a privately owned launch complex on the Cape York Peninsula that would launch Russian Proton or Zenit-3 rockets into circular and geostationary orbits. The project has been plagued with difficulties, but in 1991 it secured US$ 20 m in funding for further studies from a EuroAmerican financial syndicate.

Initially the Cape York spaceport was to have used the Russian/Ukraine Zenit-3 launch vehicle. The breakup of the Soviet Union and the subsequent turmoil between Russia and Ukraine, however, made potential investors hesitant to fund it. The Zenit-3 vehicle was designed in Russia but built in the Ukraine and, due to the economic problems in the CIS, Ukraine is now disputing the ownership of the Zenit-3 rockets. Therefore, to minimise the potential political difficulties, one of the bidding groups, Space Transportation Systems, signed a contract with Russia to use the all Russian Proton rocket, giving the vehicle a vastly increased launch capability into geostationary transfer orbit due to the launch site being closer to the equator.

Although the Cape York project is still active, one of the leading bidders involved in the project, Space Transportation Systems, was rejected by the Australian government after failing to find significant funding and has relocated to Papua New Guinea (PNG). The PNG project is basically the same as the original Cape York proposal in that it will launch the Proton vehicle, but there is one major difference in that the Russians will have a substantial role in the funding and running of it. The group has claimed that it is very close to finalising the US$ 920 m required.

The PNG project retains a large Australian content. The launch facility would be built by the Australian firm Kaiser Engineering and the associated township, airports and shipping facility by the Canberra company Australian Construction Services. It does, however, have some disadvantages over the Cape York proposal such as the political instability in PNG, possible future trade sanctions over human rights abuses there, the earthquake likelihood in the area and the underground water table of the site, which is one metre below the surface. Officials say that none of the difficulties is insurmountable. Whether or not the project will be allowed to continue will be put to a vote by the people of PNG.

Although the PNG proposal seems much more likely to succeed, the Australian Space Office claims that it does not jeopardise the viability of the Cape York venture. If all goes according to plan, which is unlikely given the history of setbacks to the programme, the first rocket will lift from the PNG Spaceport in 1998.

ISAAC GRANT BOXX

Space Debris Collaborations

'International Collaboration' has been an oft recurring theme in the pages of *Spaceflight*. In the June 1993 Issue, Space Debris was highlighted as an area of growing concern requiring International action. On p.185 of that Issue a Report was given of the main conclusions of the final European Space Debris Conference in April 1993, a meeting that attracted space experts from 17 different countries.

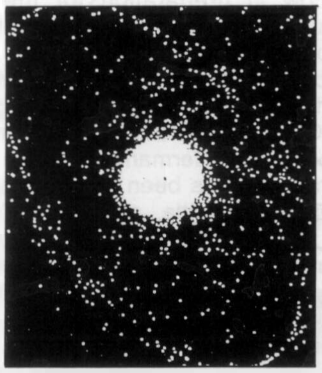
We now hear from BIS Fellow Nicholas L. Johnson of the Kaman Sciences Corporation, Colorado Springs, USA with details of two papers that he co-authored with Russian colleagues and presented at international conferences in 1993. One of these deals with debris released by Proton launch vehicles and presents the results of a successful collaborative effort between himself and fellow-worker D.S. McKnight with Russian Federation scientists, B.V. Cherniatiev of the Energiya Scientific Production Association and G.M. Chernyaskiy of the Center for Program Studies, Russian Academy of Sciences. The paper was presented at the April 1993 European Space Conference. We quote a summary of their very interesting work and findings:

> On at least six occasions during 1983-1992, operational debris released from the fourth stage of Russian Proton launch vehicles fragmented, creating up to 60 new trackable debris in Earth orbit after each event. Surprisingly, these fragmentations occurred 18-96 months following successful Proton missions. One month after the fifth incident in September, 1992, an international investigation employing American space surveillance data and analyses and Russian engineering knowledge determined the probable cause of the satellite breakups. Preventive measures are now being developed for future Proton flights. The unprecedented Russian-American cooperation leading to the resolution of this environmental issue should serve as a model for future investigations.

Nick also writes to say that he is a member of a Committee on Space Debris formed by the US National Academy of Sciences and comprising, in addition to the Chairman, of 5 Americans (including himself), 2 Europeans, 1 Russian, 1 Japanese and 1 Canadian. Their objective is to prepare a new report to be released in 1994 on the orbital debris environment.

Recently the Kaman Sciences Corporation has been working with Russian colleagues to determine the cause of the disintegration in orbit on October 18, 1993 of the 10-year old Soviet Cosmos 1484 remote sensing spacecraft. This surprising event was reported in the Satellite Digest - 260 (***Spaceflight***, January 1994, p.26).

Cosmos 1484 ceased operating in February 1984 and the orbit at the time of the breakup was 549 km by 596 km at 97.5 deg inclination. Technical de-



scriptions and a drawing of the vehicle were released by the Russians to assist in the investigation. By mid-November 1993, the Russian Space Surveillance System had identified 55 debris and the US Space Surveillance Network had identified more than 100 debris. Some debris were ejected into high altitude orbits with apogees greater than 1,300 km. Official cataloguing of debris in the US has been a protracted process.

Both collision and explosion causes are still being investigated. The Russians have acknowledged three potential energy sources on-board at the time of the breakup:

1. Four small tanks of NH_3 on the exterior of the spacecraft,
2. NiCd batteries inside the 1.4 diameter, 2 m tall equipment compartment, and
3. Internal pressurisation of the equipment compartment, probably reduced to 0.6 atm since launch.

The German FGAN radar has imaged the principal remnant of Cosmos 1484 and found that the main body and solar arrays are apparently intact. Additional radar and optical observations of the principal remnant are still being conducted.

US Astronauts for Mir

Shuttle astronauts Norman Thagard and Bonnie Dunbar will become the first US crewmembers to serve on the Russian space station Mir, under the December 1993 agreement for joint space station activities (***Spaceflight***, February 1994, p.38).

Thagard, 50 a physician who has made four flights on the shuttle, is the prime candidate for the first three-month stay aboard Mir, scheduled to begin next year. Bonnie Dunbar, who has made three shuttle flights, will serve as backup. Thagard, who will be launched in a Russian Soyuz rocket to Mir, will be the first US astronaut to fly aboard a non-US launcher.

European Astronauts for Mir

Two long-duration flights involving ESA astronauts are planned for 1994 and 1995 on board the Russian space station Mir. They have been dubbed the "EUROMIR missions". ESA staff members explain.

Since August 1993, four astronauts have been training at Star City near Moscow in preparation for the missions: the first one will last 30 days and the other 135 days. Training has been particularly intensive because time is short. The astronauts working on EUROMIR 94 (30 days in orbit) are Ulf Merbold from Germany, a space flight veteran who has been on two missions aboard the Shuttle, and Pedro Duque from Spain. The Swedish astronaut, Christer Fuglesang, and the German, Thomas Reiter, are working on EUROMIR 95 (135 days in orbit).

For each EUROMIR mission, one ESA astronaut will fly and the other will be the back-up. All four European astronauts recently completed their basic training and embarked on the second phase after the Christmas holiday period, which was a welcome break from the schedule of intensive activity.

During the break, on 17 December, Thomas Reiter, Christer Fuglesang and Pedro Duque, together with the Frenchman Jean-Francois Clervoy and the Italian Maurizio Cheli - who have both been training as mission specialists for a flight on board a US Shuttle - received their official European astronaut certificates at a ceremony held at the European Astronaut Centre (EAC), Cologne, Germany.

The Transitional Period

Until the go-ahead decision for the EUROMIR missions was taken at the 1992 Granada meeting of ministers responsible for space, the Member States of ESA had cooperated with the Russians on manned flights on an individual basis only. However, once the Russians had declared an interest in cooperation on a wider, more European basis, the European space ministers meeting gave ESA a remit to negotiate new areas of cooperation.

Russia has built up a formidable space capability and increased international cooperation is a way of sustaining and using this capability more efficiently for the benefit of all mankind. But international cooperation on large programmes, such as manned space flight, is also a must for Europe, the United States and other space-faring nations, not only in terms of cost-sharing but also because cooperation pools technical as well as human resources.

Generally speaking, the world today has nothing in common with the world as it was five years ago. Manned missions are now seen in a different light. Where there was competition, there is now international cooperation. What is taking place is in fact a merger of the Russian Mir space station with the international space station concept, thus making it "global". Distinctions are no longer drawn between the West's Freedom space station and the successor of the Russian Mir-1.

The Associate Director for Strategy, Planning and International Policy at ESA, Jean-Jacques Dordain explains:

> We are moving into the age of manned flights on a worldwide scale. Europe intends to be a full partner in this development and this means that the plans drawn up in 1987 need to be adjusted to take into account the new situation that we have now.

Working to a Deadline

Since the Mir station was not planned to be operational beyond 1995/6, Europe could not wait until some unknown future date before putting its astronauts into space and was therefore prompted to conduct negotiations with the Russians on a relatively short time-scale. The problem confronting ESA has been, and still is, the time available for preparing the programme of experiments and for training. The Russians assured ESA that one year was sufficient training for a one-month mission such as EUROMIR 94, assuming that the astronauts were of high calibre! The Russians have confirmed that the two candidates chosen for this flight fully meet the requirements for the type of mission involved. Jean-Jacques Dordain reports:

> We have a little more time for EUROMIR 95, even though this will be the first time a non-Russian will spend 135 days in space! This mission requires longer, more complex training but the Russians, who undoubtedly have more experience than us in this respect, have assured us that this is feasible.

Once the political decision had been taken, a coherent science programme had to be drawn up rapidly. ESA took up the challenge. According to Heinz Oser, the senior life scientist in the ESA microgravity programme:

> For the first flight we have chosen three main experimental themes in the life sciences. The first will concentrate on studying changes in the cardiovascular system when an astronaut goes into space, and monitoring readjustment to gravity on returning to Earth. The second theme concerns studies of the human neuro-sensory system to gain a better understanding of how certain internal mechanisms react when a human being is subject to near weightlessness. The third theme concerns the muscle system which will be measured before and after the one-month long flight in terms of muscle strength and mass. It is believed that under weightlessness conditions, muscle-weakening mechanisms are different from those on Earth. ESA has also selected five materials science experiments, which will require the use of a furnace on Mir developed by the Czechs, and two technology experiments.

For the choice of experiments to be performed on the 1994 mission, a factor to be taken into account was also the restriction on the weight of the payload to be brought back by the Soyuz capsule, which must not exceed about ten kilos. This limitation has obliged ESA to give preference to certain experiments and even cut down on others - for instance, there will be fewer urine samples than scientists originally planned. Wolfgang Nellessen, ESA Euromir Project Manager explains:

> On Soyuz, there is only limited capacity for bringing back specimens and samples in addition to the cosmonauts. This means we have to decide which products should be brought back as a priority and, in the event, which biological blood, urine and saliva samples will return to Earth with the European astronaut. The materials sciences samples may have to stay on Mir until one of the US-Russian missions, when a Shuttle will dock with the station and could bring them back.

The Shuttle will visit Mir up to ten times over the period 1995 to 1997, foreshadowing the development of a global station. Since EUROMIR 95 is to take place during the period in which US Shuttles will fly to Mir, it may be possible to use the Shuttle flights to carry equipment to Mir and return to Earth samples from experiments carried out during the EUROMIR 95 mission. The Shuttle could therefore be used to considerably enhance the EUROMIR 95 operations.

135 Days in Orbit

The most distinctive feature of the EUROMIR missions is the exceptionally long time that the astronauts will spend in space. It will be far longer than the 8 to 14 days spent on Shuttle flights and will enable much more data to be gathered, Heinz Oser explains:

> For the first flight, lasting 30 days, we have sought to make maximum use of the equipment already on board Mir. However, for the second mission, planned to last 135 days, there is more time to develop new hardware involving European firms. Experiments envisaged are a biokit, which will enable us to expose biological samples to microgravity and cosmic radiation, and an instrument able to measure changes in an astronaut's bone density

as bones tend to become brittle during long-duration missions because of demineralisation.

Several research institutes, most of them attached to European universities, will be taking part.

Astronaut Workloads

Around 100 hours of scientific experimentation will be allocated to the European astronaut on EUROMIR 94 and about 450 hours for EUROMIR 95. In addition, the Russian cosmonauts will provide support for the ESA experiments. According to Wolfgang Nellessen:

> During each EUROMIR mission, the ESA astronaut will work a daily shift of a maximum of twelve hours of which up to six hours are dedicated to scientific work. Saturdays and Sundays are rest days. By fixing the weekly work period for experiments at about 25 hours and given that the European astronaut will work for four weeks on the EUROMIR 94 mission, a hundred or so hours will be spent carrying out the mission's scientific programme.

An astronaut frequently has a heavy workload given that it takes much longer to carry out an experiment in space than on Earth!

Global Space Station

The EUROMIR flights are considered as precursors of European participation (through the Columbus programme) in the global space station.

In the words of Mr F. Engström, ESA's Space Station and Microgravity Director:

> Using the global space station means that long-duration missions will be necessary as you cannot change astronauts every week! At present, it is planned to change crews on a permanently manned space station every three to six months. With the two EUROMIR missions, Europe is therefore preparing its astronauts for the forthcoming global space station era. Furthermore, this is an excellent opportunity to perform scientific experiments as well as to prepare the user community for that era.

ESA-Poland Agreement

An agreement, covering cooperation on the exploration and use of outer space for peaceful purposes, was signed between the European Space Agency (ESA) and the Republic of Poland on 28 January at ESA Headquarters in Paris. The agreement is an expression of ESA's political will to cooperate with the countries of central and eastern Europe as reaffirmed by the ESA Council meeting at ministerial level in Granada.

This is the third agreement that ESA has concluded with a country in central or eastern Europe, the first having been signed with Hungary in April 1991 and the second with Romania in December 1992.

External Servicing of Space Stations

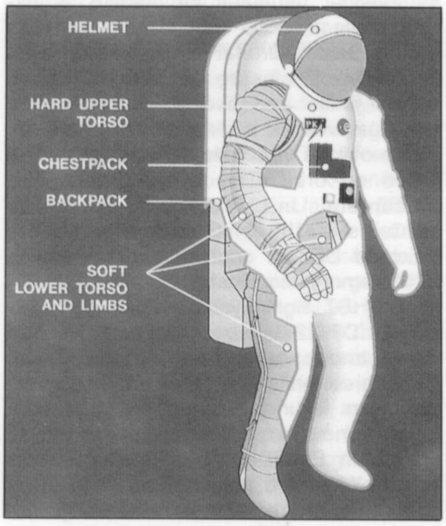
ESA Cooperation with Russia

Throughout all of the options and re-orientations of the Hermes programme and its European Manned Space Transportation programme successor, the need for external servicing of space infrastructure has remained apparent. During late 1991/early 1992 an intensification of dialogue with the Russian Space Agency occurred and within the framework of overall ESA/RKA cooperation a working group was established to evaluate this subject.

The inter-agency working group has been backed up by considerable industrial and institutional effort both in Europe and in Russia. The principal elements, from the ESA standpoint, were:

- the External Robotic Arm (ERA) and
- the Extra Vehicular Activity (EVA) space suit.

For ERA, the idea is that ESA develops the robotic arm for servicing Mir-2 and supplies it to the RKA for them to operate on the station. In exchange ESA could expect some access to the Mir-2 facility for utilisation and research purposes.

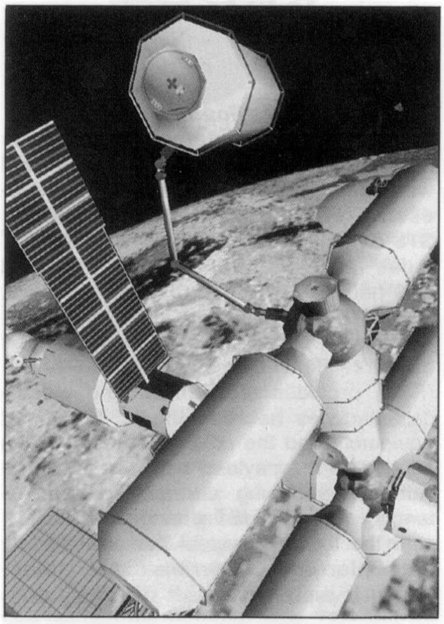


Advanced EVA Suit 2000. ESA

In contrast the EVA Suit 2000 development is foreseen as a genuinely joint development between the two Agencies, both eventually funding their own responsibilities and making use of individual capabilities.

Other topics such as training, flight operations, on-orbit equipment maintenance have been addressed within the working group to ensure that a complete 'package' is defined.

For ESA personnel, working with their Russian colleagues has proved to be both enjoyable and difficult; the latter being exclusively related to the problems of real-time communication (verbal and written). The language



The ERA operational on the Mir-2 configuration in its servicing role. ESA

problem is slowly being overcome by intensive language courses plus considerable translator expenditure.

For written communication a large effort has been spent in installing mainframes, personal computers and modems at the RKA and Russian prime contractor facilities to enable electronic links to be established. These difficulties are more than offset by the camaraderie and professionalism exhibited by both sides.

The result of these efforts to date is summarised briefly in the two illustrations. The former shows the principal features of the advanced EVA Suit 2000 system, which was planned to be operational by the end of this century on Mir-2. Possibilities in connection with a 'Global Station' have also been addressed and discussed.

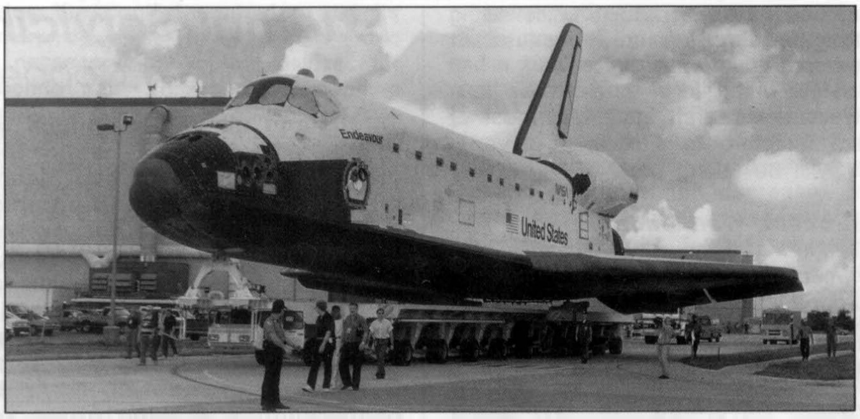
The illustration above shows the ERA operational on the Mir-2 configuration in its servicing role. For both elements, RKA, supported by its industrial prime contractors, has requested that delivery be advanced to support the assembly phase of the station, and this is under evaluation. The basis for this request is the Russian assessment that both ERA and EVA Suit 2000 would enhance the efficiency and the safety of the stations, and this they want 'from day 1'.

So, to date, cooperation with the Russians on the external servicing of stations can be said to be 'proceeding in a positive direction'.

Based on an edited version of 'Cooperation with Russia on external servicing of space stations' by A. Thirkettle in Reaching for the Skies No. 10, December 1993, ESA Publications Division.

– STS-61: Mission Report

Hubble Repair Mission



The orbiter being moved from the OPF-1 to the VAB on 21 October. NASA

BY ROELOF L. SCHUILING
at the Kennedy Space Center

Endeavour's Payload

Endeavour completed its previous mission, STS-57, on 1 July 1993 and was then rolled into the Orbiter Processing Facility-One (OPF-1) for the STS-61 mission. Elements of the HST repair payload had arrived In August and had been prepared for Installation.

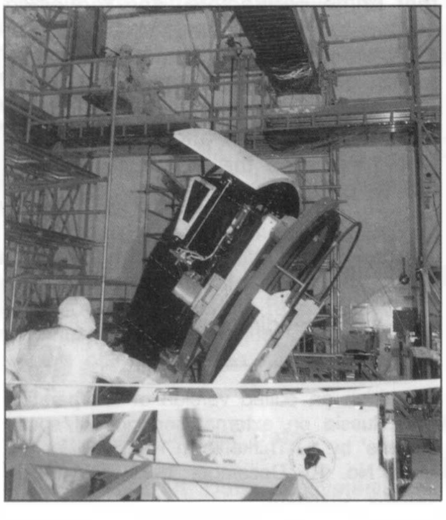
The payload included a Flight Support System, replacement components and carriers. The Flight Support System (FSS) provides mechanical and electrical interfaces between the HST, support equipment and the orbiter. Mounted in the aft end of the payload bay, the FSS provided the berthing and positioning system to hold the HST during operations.

In the forward area of the payload bay the Solar Array Carrier (SAC) transported a replacement set of solar arrays for the HST, and returned the original pair to Earth.

Located in the central area of the payload bay was the Orbital Replaceable Unit Carrier (ORUC) which contained replacement instruments and crew aids and tools.

The Radial Scientific Instrument Protective Enclosure contained the replacement Wide Field Planetary Camera (WFPC-II). This second generation instrument updated the HST's dual mode camera with more photometrically stable charge-coupled devices. WFPC-II was a spare instrument developed by the Jet Propulsion Laboratory that built the first WFPC that was installed in HST prior to launch. When the HST mirror was found to be flawed the development team began working on an optical correction that could be built into WFPC-II. The new instrument incorporates a correction by refiguring the relay mirrors in the optical train of the cameras. This refiguring compensates for the incorrect figuring of the HST mirror.

The WFPC-II is hoisted to a vertical position for installation on the Scientific Instrument Protective Enclosure (SIPE) which will carry it into orbit. NASA



The Axial Scientific Instrument Protective Enclosure contains the Corrective Optics Space Telescope Axial Replacement (COSTAR). Costar is designed to optically correct the effects of the primary mirror aberration on three other instruments besides WFPC. These are the Faint Object Camera, the Faint Object Spectrograph, and the Goddard High Resolution Spectrograph. COSTAR was invented by the HST Strategy Panel, a group of scientists and engineers brought together at the Space Telescope Institute, Baltimore, Md, in the fall of 1990 to consider remedies for the HST's mirror problem.

The Small Orbital Replacement Unit Protective Enclosure houses three rate sensor units and two electronic control units as well as an instrument repair kit. Three of HST's six rate sensing gyros had failed on orbit. The Large Orbital Replacement Unit Protective Enclosure contains the Goddard/Lockheed/Fairchild DF-224 coprocessor and a DF-224 memory modification kit. The DF-224 is the HST flight systems computer. One of the DF-224's six memory units had failed and another had partially failed. Only three units are required to operate so these failures had not affected HST operations.

Also in Endeavour's payload bay was an IMAX camera mounted so as to cover the mission operations. An additional hand-held IMAX was carried in the crew compartment.

The Launch

The Flight Readiness Review was held on November 17 and mission managers confirmed December 1 as the launch date.

After a short break for the November 25 Thanksgiving holiday, final preparations for picking up the launch countdown were made. The flight crew returned to KSC on Saturday November 27 with the countdown set to begin at 9:00 am on the 28th.

The launch countdown picked up on time at the T-43 hour point. A potential complicating factor was avoided when an Atlas-2 was successfully launched from Launch complex 36 on the evening of the 28th, thus releasing tracking, range safety and support services for STS-61.

The weather picture, however, did not look good as the STS-61 launch time approached and as the countdown reached the last built-in-hold at T-9 minutes the weather conditions were not acceptable and the launch team elected to stay on hold. Then, as time was getting short, they resumed the count and went to T-5 minutes in order to be in a posture to resume launch countdown quickly if the weather improved. Shortly before the launch window time ran out it was determined that no possible launch attempt could be made that day and the launch was scrubbed for December 1.

With an improving weather forecast, the launch was recycled for the following day with the countdown clock supporting a T-0 at 4:27 am on Thursday December 2. Orbital parameters caused the launch to move about a half-hour earlier for the second launch attempt.

The crew left for the launch pad after breakfast and arrived at the white room adjacent to Endeavour's hatch at about 1:45 am on the 2nd.

The final hours of the countdown were without major incident. At T-0 the SRB engines fired and the main engines were at 104 percent thrust as STS-61 lifted off.

At launch plus 27 seconds the SSMEs were throttled down to approximately 70 percent to reduce loads during maximum dynamic pressure (Max-Q) and at T+57 seconds throttled back up to 104 percent.

SRB staging occurred at T+2:06. The SRBs then descended to approximately 15,400 feet where nose cap jettison and drogue parachute deploy occurred. At about 6,600 feet above the ocean the drogues were released and the main parachutes deployed to provide final deceleration before the SRBs impacted the ocean and were retrieved.

At launch plus 8 minutes and 25 seconds the SSMEs were throttled down to 67 percent in preparation for Main Engine Cut Off (MECO) which came at 8 minutes 32 seconds. The engines reached zero-thrust approximately 7 seconds later. At 8 minutes 49 seconds the External Tank was jettisoned and Endeavour's Reaction Control System imparted an 11 ft/s separation velocity.

At 43 minutes into the flight the manoeuvring engines burned for about 4 minutes and 48 seconds to place Endeavour into its 310 nautical mile orbit and the mission was underway.

About the Crew

The STS-61 crewmembers were chosen for the experience and skills which they brought to the Hubble repair mission. The Mission Commander was ***Richard O. Covey***, 47, Col., USAF who had previously participated in the orbital rendezvous and repair of the SYNCOM IV-3 satellite on STS-51-I in August 1985 and the return-to-flight mission of STS-26R in September 1988. He was also the Commander on STS-38 which was the first orbiter landing at KSC of the post-Challenger era in November 1990. Covey was selected as an astronaut in 1978 and had over 385 hours in space prior to STS-61.

STS-61's Pilot was ***Kenneth D. Bowersox***, 37, Cmdr, USN, who had flown previously on STS-50 in June 1992, which at the time was the longest Shuttle mission of the programme with over 331 hours in space. He was selected as an astronaut in 1987.

Payload Commander, and Mission Specialist-4 was Dr F. Story Musgrave, 58. A medical doctor, Musgrave was making a record fifth flight in space. He was one of the first astronauts to perform EVA operations and had helped plan the EVA operations for the STS-49 Intelsat repair mission. Musgrave had logged more than 598 hours in space during his flights aboard STS-6 in April 1983, STS-51F in July-August 1985, STS-33R in November 1989 and STS-44 in November 1991. Musgrave was selected as an astronaut in 1967.

Musgrave and Mission Specialist-3 ***Jeffrey A. Hoffman***, 49, PhD made up one of the mission's EVA teams. Hoffman, who was selected as an astronaut in 1978, made the first contingency EVA of the Shuttle programme during his STS-51D mission in April 1985. He also flew as Mission Specialist on the STS-35 mission in December 1990 and STS-46 in July 1992 and had accumulated over 574 hours in space flight time.

The second EVA team members were Mission Specialist-5 ***Tom Akers***, 42, Lt. Col., USAF and Mission Specialist-1 ***Kathryn C. Thornton***, 41, PhD. Astronaut Akers served as a mission specialist on STS-41 in October 1990 and on STS-49 in May 1992. During the STS-49 mission Akers was one of the three-man EVA team that captured and repaired the Intelsat satellite. A 1987 astronaut selectee, he had over 311 hours of space flight time before STS-61. Kathryn Thornton was selected as an astronaut in 1984 and had previously flown on STS-33 in November 1989 and on STS-49 in May 1992. She had logged over 333 hours of space flight time.

Claude Nicollier, 49, was Mission Specialist-2 and was responsible for operating the Shuttle robot arm. The Switzerland-born astronaut was selected by NASA in 1980 under a joint ESA-NASA agreement. He had previously flown on the STS-46 mission in July 1992 and had more than 191 hours in space.

The traditional inflight photo of the crew. Left to right: back row - F. Story Musgrave, Jeffrey A. Hoffman, Kathryn D. Thornton and Thomas D. Akers and front row - Claude Nicollier, Kenneth D. Bowersox and Richard O. Covey. NASA

Mission Operations Day-by-Day

Flight Day One

After arriving on-orbit Mission Commander Covey fired the Orbital Manoeuvring System (OMS) just before 10:00 am for the first of several burns designed to adjust the rate at which Endeavour was closing on the Hubble Space Telescope.

Flight Day Two

The primary activities involved the checkout by EVA astronauts of the space suits. Meanwhile astronaut Claude Nicollier activated the RMS to warm it up. He also surveyed the payload bay using a camera on the RMS to make sure that all was well with the HST repair equipment. Also in preparation for the planned EVA activity, the crew reduced the pressure in the cabin from 14.7 psi to 10.2 psi.

Two more manoeuvring engine burns adjusted the rate of approach to the HST. A third burn designed to place Endeavour in the same orbit as HST was not required due to the precise performance of the orbiter during ascent.

The Space Telescope Control Center at Goddard Space Flight Center (STOCC) sent commands to the telescope to move it into its proper solar inertial attitude for the upcoming rendezvous.

Flight Day Three

Endeavour was about 190 nautical miles behind the HST as the crew awakened and was closing in on its target at about 60 nautical miles per orbit. A reaction control system (RCS) burn at about 9:34 pm brought the orbiter to a point 40 nautical miles behind HST. About fifty minutes later an OMS burn changed Endeavour's velocity by about 12.4 ft/s and adjusted the closing rate to 16 nautical miles per orbit to place it eight nautical miles behind HST two orbits later.

A third burn came shortly before 11:00 pm and was the first burn calculated by onboard computers using star tracker sightings of HST and onboard navigation systems. The burn made small adjustments in the orbiter's course as it closed on a point eight nautical miles behind HST. The multiaxis Terminal Initiation (TI) burn after 1:30 am on December 4 placed Endeavour on an intercept course and set up Mission Commander Covey's manual control of the final stages of intercept.

Endeavour manoeuvred to within 30 feet of the telescope and Claude Nicollier used the RMS to grapple the HST at 3:48 am. By 4:26 am the HST was securely berthed in the payload bay.

Flight Day Four

The primary goals for the first EVA team of Story Musgrave and Jeff Hoffman involved the replacement of two of the HST's gyroscope rate sensor packages, two electronic control units and eight fuse plugs that protect the electrical circuits.

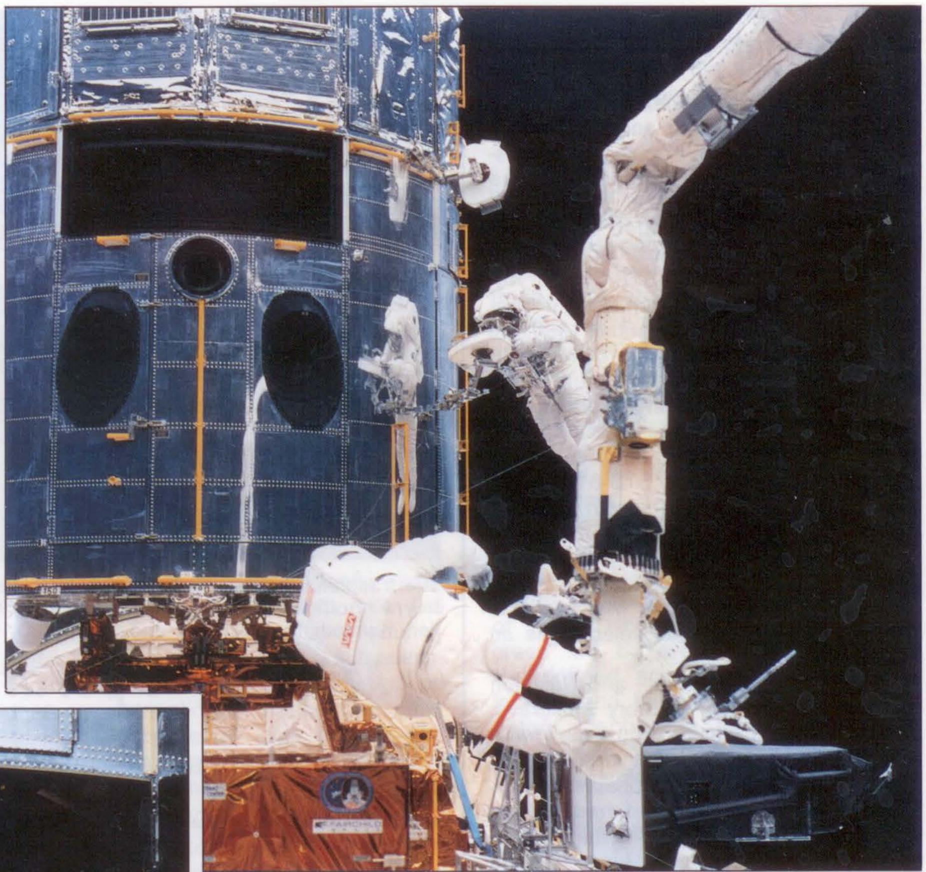
Flight Day Five

Mission Specialists Thornton and Akers were the EVA team and their primary goal was to replace the HST solar arrays.

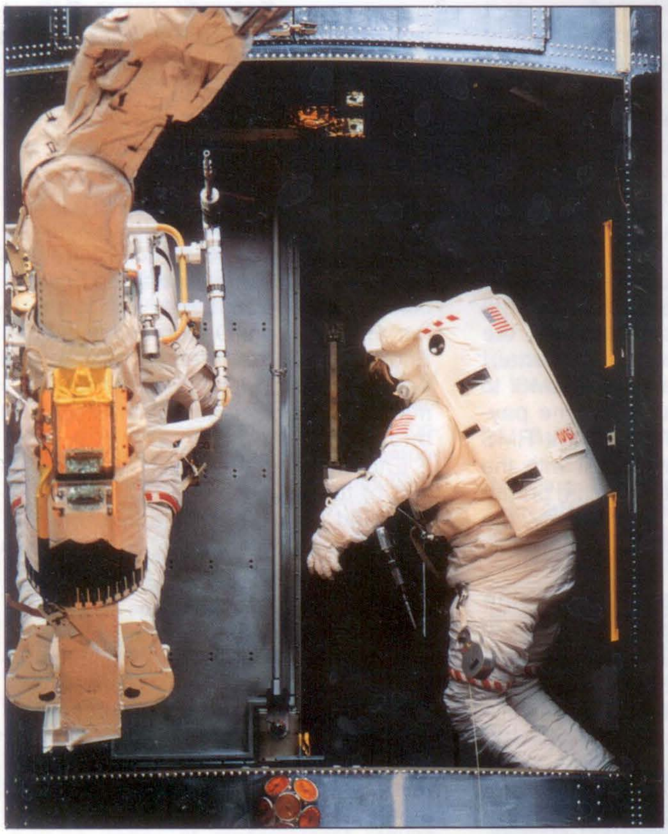
The first chore was the detachment and jettisoning of the right solar array, which had failed to completely retract due to a kink in the array framework.

Kathy Thornton lifted one of the replacement solar arrays from its payload bay carrier and installed it on the HST. The duo then installed the remaining old array in the carrier and set about installing the second new array on the telescope.

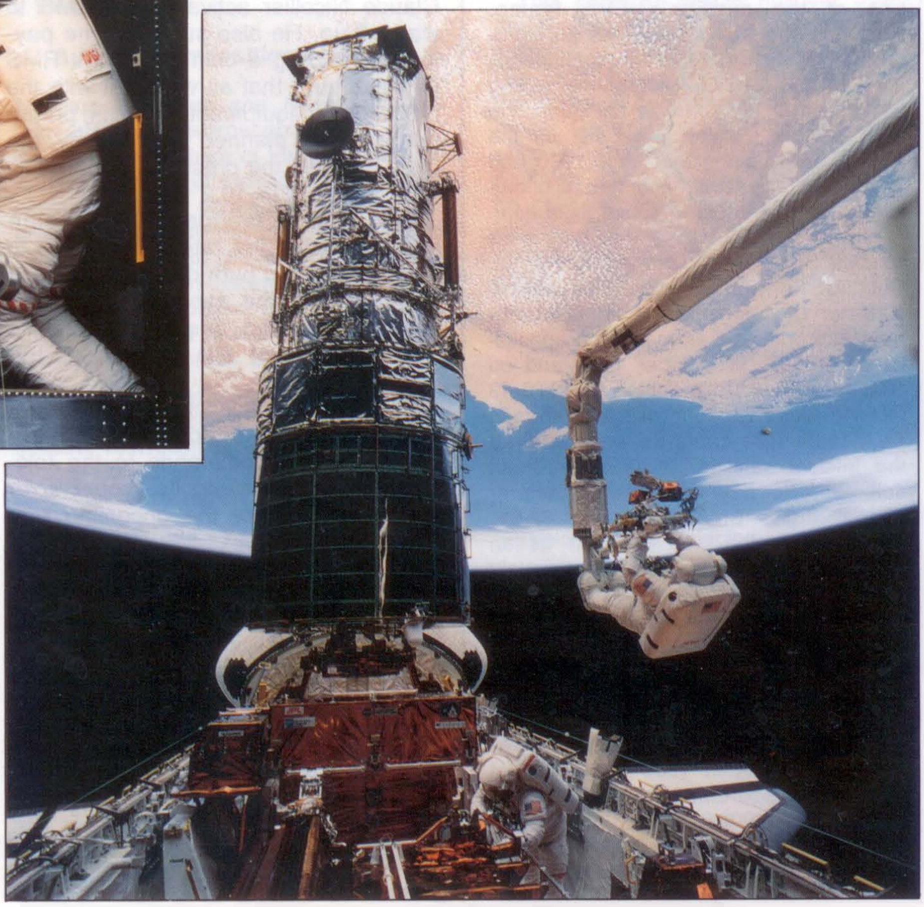
Hubble Space Telescope Serviced and Refurbished



Right: Flight Day Six - Anchored on the end of Endeavour's Remote Manipulator System (RMS) arm, Jeffrey A. Hoffman (foreground) prepares to install the new Wide Field Planetary Camera (WFPC II) into an empty cavity (top left) on the Hubble Space Telescope (HST). WFPC I is seen temporarily stowed at bottom right. Astronaut Story Musgrave works with a Portable Foot Restraint (PFR) at the centre of the picture as his image is reflected in the shiny surface of the telescope. NASA



Left: Flight Day Seven - Thomas D. Akers manoeuvres inside the bay which will house the corrective optics space telescope axial replacement (COSTAR) while assisting Kathryn C. Thornton with the installation of the 640-pound instrument. Kathy Thornton, anchored on the end of the Remote Manipulator System (RMS) arm, is partially visible as she prepares to install the COSTAR. NASA



Right: Flight Day Eight - Story Musgrave, anchored on the end of the Remote Manipulator System (RMS) arm, prepares to be elevated to the top of the towering Hubble Space Telescope (HST) to install protective covers of magnetometers. Jeffrey A. Hoffman (bottom of frame) assisted Musgrave with final servicing tasks on the telescope, wrapping up five days of space walks. NASA

Flight Day Six

Replacement of Hubble's Wide Field Planetary Camera (WFPC) was the major task of the day as the crew performed the third EVA of the mission. The EVA team of Musgrave and Hoffman did the job with Claude Nicollier assisting with the RMS operation.

About 35 minutes after the installation, ground controllers performed an "aliveness" test of the new WFPC. Later in the morning, controllers at STOCC, Goddard successfully put the new unit through a functional test.

The next business for the EVA astronauts was the replacement of two new magnetometers near the top of the HST. The telescope was tilted forward on its work platform so that the robot RMS arm could reach the required area. With Hoffman and Musgrave both at the end of the RMS arm the magnetometers were both successfully replaced.

Flight Day Seven

Tom Akers and Kathy Thornton performed "successful eye and brain surgery" on the HST, the goal for the day being the installation of the Corrective Optics Space Telescope Axial Replacement (COSTAR) unit and a DF-224 computer coprocessor.

Their first operation was the removal of the High Speed Photometer from the HST and the replacement of that unit with the COSTAR package. Telescope controllers at STOCC, Goddard turned off the power to the photometer and then Thornton, positioned at the end of the robot RMS arm, opened the access door latches using a power ratchet tool. Akers climbed inside the compartment and disconnected the photometer ad then helped to move the 7 by 3 foot 487 pound unit along its guide rails. Thornton then held the photometer as Nicollier manoeuvred her and the instrument back away from the HST to a position where she could place the photometer on a holding fixture on the payload bay.

Thornton was then positioned above the COSTAR storage compartment and with the help of Nicollier's RMS operations, she removed the 640 pound instrument and positioned it in front of the HST opening. Akers, inside, helped to align the unit on the guide rails and the two astronauts moved the new unit inside the HST.

Akers and Thornton completed the task in a record time of 35 minutes instead of the scheduled 3 hour and 10 minutes. The two EVA astronauts then placed the old High Speed Photometer which they had removed into the payload bay stowage compartment which had held COSTAR for return to Earth. The DF-224 computer coprocessor was then installed, its installation being likened to brain surgery and the COSTAR installation to eye surgery.

Flight Day Eight

At approximately 9:30 pm on December 8, Endeavour's orbit was circularised in preparation for the later release of the HST.

The fifth and last EVA had Jeff Hoffman and Story Musgrave as the EVA duo. The EVA activity began at 10:30 pm on 8 December, the first order of business being the replacement of the solar array drive electronics. The replacement was complete about 2:00 am on the morning of the 9th.

The astronauts next turned to the installation of the Goddard High Resolution Spectrograph Redundancy Kit on the telescope. This was completed by 3:30 am. The two astronauts were then moved to the top of the telescope to install protective covering for the two remaining original magnetometers.

Solar array deployment operations began at 5:05 am with the first array and about 5:30 am with the second. Each array deployment took about five minutes.

With the completion of the day's 7 hour and 21 minute EVA, the STS-61's record setting five EVAs had lasted a total of 35 hours and 28 minutes.

Flight Day Nine

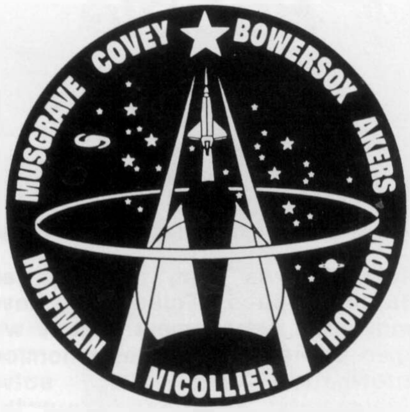
Endeavour was now in a 320 by 321 nautical mile orbit and the release of the telescope from its repair berth was the major activity.

Prior to the release STOCC, Goddard prepared the HST by loading navigation tables into its computer and powered up the reaction wheel and magnetic torquer assemblies. Claude Nicollier grasped the HST with the robot arm's end effector. The crew inside the Endeavour later disconnected the Shuttle's electrical umbilical from the HST and opened the berthing latches holding the telescope in the orbiter's payload bay. After Nicollier raised the HST out of the payload bay, telescope controllers began the 33 minute long sequence to open the HST's aperture door.

Following the release of the HST, two small separation burns were performed to gently move Endeavour away from the HST at 1 ft/s.

Flight Day Ten

The crew used the IMAX camera in the payload bay to record images of Earth, repressurised the cabin back to 14.7 psi, performed water dump investigations for possible space station use and conducted additional space suit evaluations. The RMS robot arm was tucked away in



its stowed position in the payload bay.

Flight Day Eleven

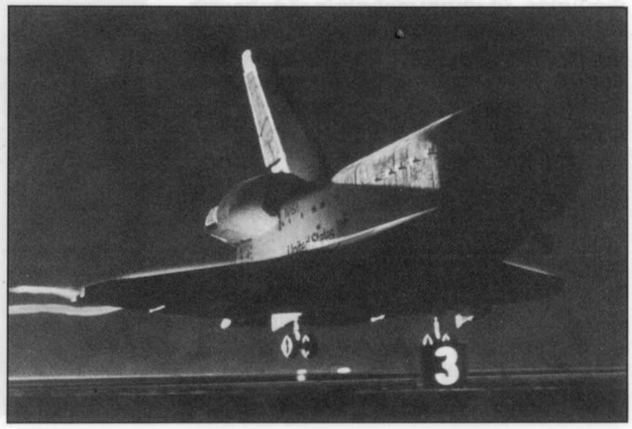
The crew spent their last full day in space preparing for their landing at the Kenned Space Center. An RCS hotfire test was performed and the payload bay IMAX camera deactivated. Covey and Bowersox also practised simulated landings using the laptop computer called PILOT.

Flight Day Twelve

The astronauts put on their pressure suits and made ready for the deorbit burn which came at about 11:15 pm on the evening of December 12. Endeavour's approach path to the Kennedy Space Center took it over Mexico and across the Gulf of Mexico as it passed south of the Mission Control Center at Houston. The orbiter crossed the Florida coastline north of Tampa and crossed the state passing near Orlando.

A double sonic boom announced its arrival over Kennedy Space Center as Endeavour began a wide turn to runway 33. Touchdown was at 12:26 am on the morning of December 13 after a flight of 10 days 19 hours and 59 minutes. Main landing gear touchdown was at 12:25:33 am at the 2,900 foot mark. Drag chute deployment came at 12:25:45. The drag chute was jettisoned prior to the wheels stop to prevent it snagging on the orbiter's engines. Wheels stop was at 12:26:25 at the 10,800 foot mark. ■

The orbiter Endeavour touched down at 12:25:33 am EST on December 13 for a night time landing on Runway 33. NASA



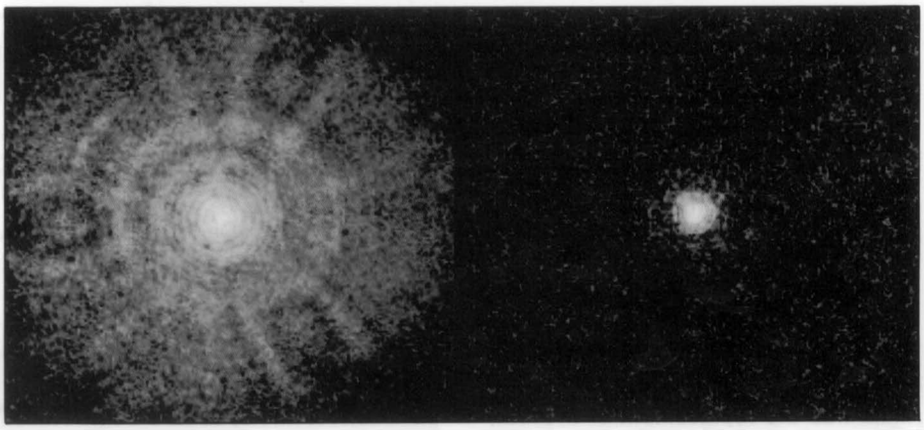
Hubble Trouble is Over

First Results Exceed Expectations

New pictures from the repaired Hubble Space Telescope have convinced astronomers that it will open up new areas of astronomical information and help solve fundamental questions about the universe. The repaired telescope can resolve very faint stars - even when they lie near brighter ones - and can now see 10 times farther than any ground-based telescope.

Before and After

The pair of images shown above right are of a single star, taken with ESA's Faint Object Camera (FOC), and demonstrate that the telescope has been restored fully to its planned optical performance. The COSTAR (Corrective Optics Space Telescope Axial Replacement) mirrors have removed the effect of spherical aberration in the telescope's primary mirror.



Left: An FOC image of a star taken prior to the installation of COSTAR. The broad halo (one arc second diameter) around the star is caused by scattered unfocussed starlight.
Right: Following the installation of COSTAR, the FOC met its pre-launch specifications. Most of the starlight is concentrated into a 0.1 arc second circle and the blurry "skirt" of light is completely gone. ESA/NASA

Gas Shell around Nova Cygni 1992

The new HST image (lower right) reveals an elliptical and slightly lumpy ring-like structure, which is the edge of a bubble of hot gas blasted into space by the nova. The shell is so thin that the FOC does not resolve its true thickness, even with HST's restored vision.

An HST image taken on 31 May 1993 (lower left) provided the first glimpse of the ring and a mysterious bar-like structure. But the image interpretation was severely hampered by HST's optical aberration. A comparison of the two images, reveals that the ring has evolved in the seven months that have elapsed between the two observations, expanding from a diameter of approximately 74 to 96 billion miles.

The bar-like structure seen in the earlier HST image has disappeared. The bar might have been produced by a dense layer of gas thrown off in the orbital plane of the double star system, which has subsequently grown more tenuous causing it to fade. The ring has also grown noticeably more oblong since the earlier image, suggesting that the hot gas is escaping more rapidly above and below the system's orbital plane. Nova Cygni is 10,430 light years away (as measured directly from the ring's diameter).

Spiral Galaxy as now Seen by Hubble

Though the spiral galaxy M100 lies several tens of millions of light-years away, the modified optics incorporated within the WFPC-2 allow Hubble to view M100 with a level of clarity and sensitivity previously possible only for a very few nearby galaxies. By expanding the region of the universe that can be studied in such detail a thousand fold, the WFPC-2 will help to show how our own galaxy came to be.

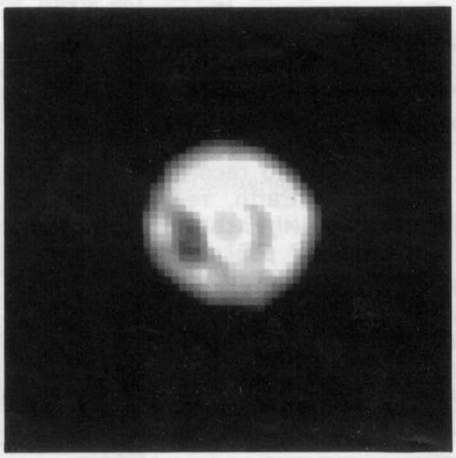
Resolving Individual Stars

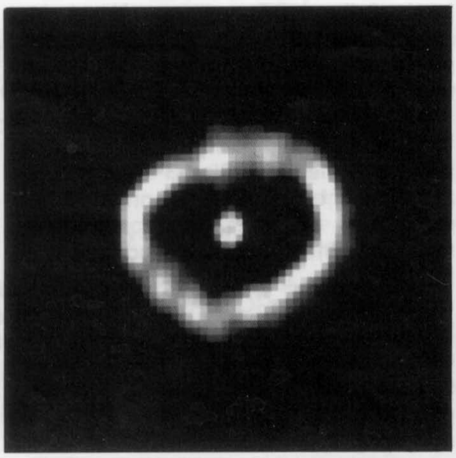
One of the greatest gains of the high resolution provided by Hubble is the ability to resolve individual stars in other galaxies. The new camera not only allows astronomers to separate stars which would have been blurred together at the resolution available from the ground, but also allows them to accurately measure the light from very faint stars. The quantitative study of compositions, ages, temperatures and other properties of stars and gas in other galaxies will provide important clues about how galaxies form and evolve.

Scale of the Universe

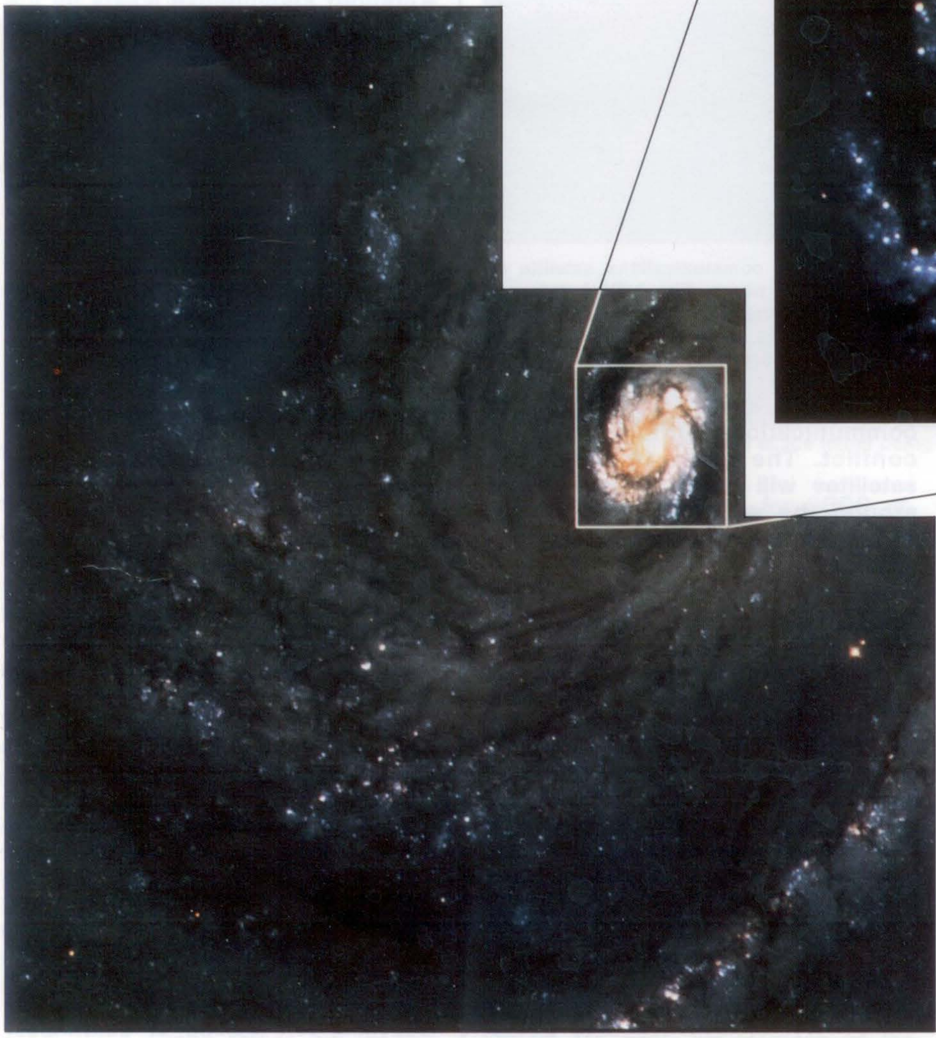
The WFPC-2 will allow an attack on one of the most fundamental questions in science: the age and scale of the universe. Astronomers have many "yardsticks" for measuring the scale of the universe, but they lack a good knowledge of how long these yardsticks really are. M100 is a member of the Virgo Cluster of galaxies. By allowing astronomers to resolve and measure individual stars in the Virgo Cluster, in particular a special type of star called Cepheid variables which have well known absolute brightnesses, HST observations are expected to provide a crucial measurement of this needed scale. Only Hubble can make these types of observations as Cepheids are too faint and the resolution too poor, as seen from ground-based telescopes, to separate their images in such a crowded region of a distant galaxy.

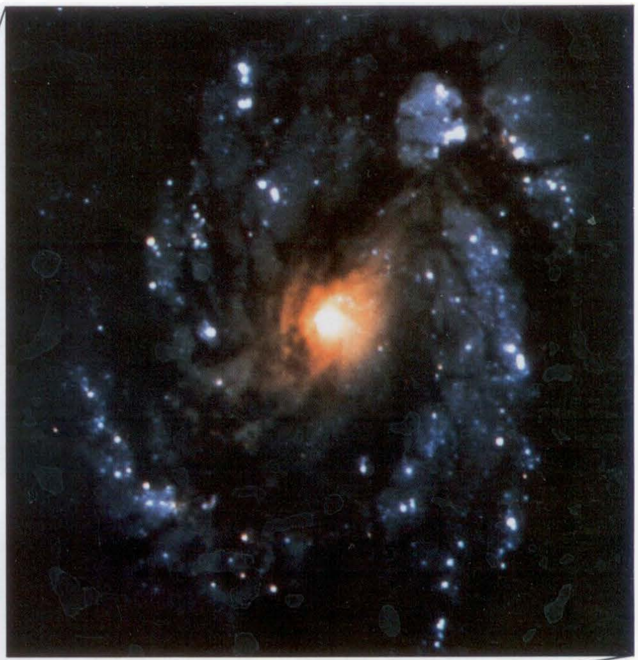
Hubble's Faint Object Camera (FOC) has given astronomers their best look yet at a rapidly ballooning bubble of gas blasted off a star. The shell surrounds Nova Cygni 1992, which erupted on 19 February 1992. ESA/NASA





The picture below is a mosaic of the three wide field cameras and the planetary camera which make up the WFPC-2. The three wide field detectors in the camera reveal individual stars and filamentary dust lanes in the outer arms of this majestic spiral galaxy. **ESA/NASA**





Above: the instrument's planetary camera image resolves complex structure in the core of the galaxy, which is the site of vigorous star formation.

The image was taken on December 31, 1993 through red, green and blue filters to create a true colour picture. Blue corresponds to the light from young and massive stars that have recently formed along the spiral arms. The pinkish blobs are huge clouds of glowing hydrogen gas. They identify sites of new star formation. The field of view is about two and a half arc minutes across. **ESA/NASA**

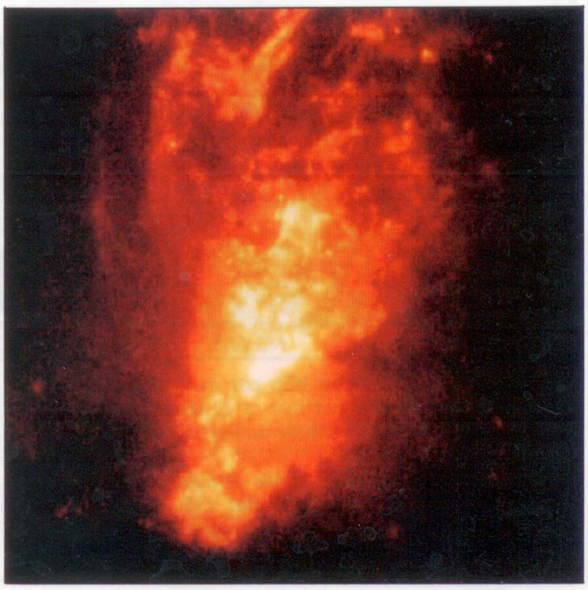
Central Region of an Active Galaxy

The refurbished HST has provided this outstanding image of the nuclear region of the galaxy NGC1068.

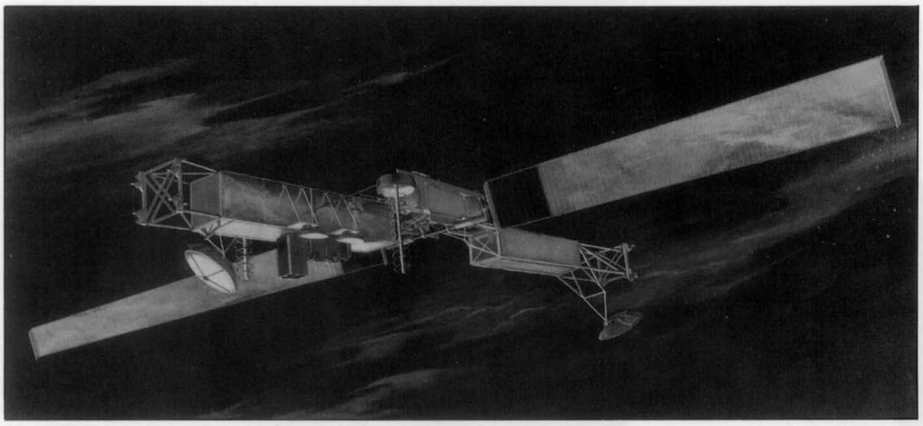
NGC1068 is located at a distance of approximately 60 million light years and is the prototype of a class of galaxies, known as Seyfert Type 2. In active galaxies, the core shines with a typical brightness of a billion solar luminosities, and the brightness of the core fluctuates over a period of a few days implying that the energy is being released from a region only a few light-days in extent. The most likely source for this enormous amount of energy is a "super massive" black-hole with a total mass of 100 million stars like the Sun.

In the case of NGC1068, previous HST observations have shown a number of hot gaseous clouds ionized or heated by the intense radiation from the nuclear source. The new observations show with unprecedented clarity a much more extensive area of emission, produced by radiation from the active nucleus. An incredible wealth of new and previously unsuspected filamentary detail is also revealed in this near-nucleus gas, embedded within the diffuse emission. The knots and streamers of emission will enable the geometry of this fascinating nuclear region to be understood, and will offer new information on the nature of the clouds themselves.

ESA/NASA



Titan Launch of Milstar



This artist's concept depicts the antenna suite of the Milstar communications satellite on orbit. The crosslink antennas are at the end of the satellite wings. The helical antennas are UHF communications. The circular antennas mounted on the side of the wing are two of three directional spot beams (the third is hidden by the wing structure). The box-shaped antennas on the underside of the wing are the agile-beam antennas. LOCKHEED

A Titan 4 rocket - the first to be launched since a similar craft exploded in August - boosted into orbit on 7 February a $1 billion military communications satellite of the Milstar satellite system, designed during the Cold War to provide secure, jam-proof communications during a nuclear conflict. The giant 10,000-pound satellites will allow military forces around the world to have instant access to a global communications network.

New Mars Programme

NASA will continue to explore Mars with a new exploration strategy in fiscal year 1995. The Mars Surveyor programme calls for the development of a small orbiter that will be launched in November 1996 to study the surface of the red planet and will lay the foundation for a series of missions to Mars in a decade-long programme of Mars exploration. The missions will take advantage of launch opportunities about every 2 years as Mars comes into alignment with Earth.

The orbiter will be small enough to be launched on a Delta expendable launch vehicle and will carry roughly half of the science payload that flew on Mars Observer, which was lost on August 21, 1993. The specific instruments will be selected later.

The orbiter planned for launch in 1998 will be even smaller than the initial Mars Surveyor orbiter and will carry the remainder of the Mars Observer science instruments. It will act as a communications relay satellite for a companion lander, launched the same year, and other landers in the future, such as the Russian Mars '96 lander. The US Pathfinder lander, set to land on Mars in 1997, will operate independently of the Mars orbiter.

New Weather Satellite

Space Systems/Loral has delivered GOES-I, the first in a series of five next-generation US weather forecasting satellites, to Kennedy Space Center, Florida, in preparation for an April 12 launch. Once launched, GOES-I will be renamed GOES-8 and after orbital check-out will be positioned at 75 degrees west longitude, complementing GOES-7, which will occupy 135 degrees west longitude. The next satellite in the series, GOES-J, will be launched in April 1995 into the orbital position now occupied by GOES-7, which will then be used as a back-up.

The delivery of GOES-I marks the beginning of a new era in weather forecasting. GOES-I will provide more precise and timely weather observation and atmospheric measurement data, due to Space Systems/Loral's flight-proven three-axis stabilised satellite design that allows the satellite sensors to continuously view the Earth for 24-hour observation of severe storms. Current spin-stabilised satellites view the Earth only 5% of the time.

Atlas Launches Telstar Satellite

A modified Atlas rocket with extra boosters for 750 kg of added lift propelled the first of three new AT&T television satellites into orbit on 15 December 1993 after a night-time launch from a rented pad at Cape Canaveral Air Force Station at 7:38 pm EST, 16 minutes behind schedule because of technical problems. General Dynamics Corp said the first flight of its Atlas 2AS was flawless.

Telstar 401 and a twin to be launched on Ariane will replace an earlier series which relay entertainment and educational broadcasts in the United States, Puerto Rico and the US Virgin Islands.

Telstar 401's clientele will include US television networks ABC and PBS, as well as the distributors of popular US shows such as "Wheel of Fortune", "Jeopardy", "Star Track: The Next Generation" and "Entertainment Tonight". The third satellite is being built as a spare, and the second Atlas 2AS will be reserved to launch it late in 1994 or early in 1995.

Australian Landing Site

The Woomera rocket range in South Australia is to be the landing site for a German satellite. According to Science Minister Chris Schacht, Australia will sign a treaty with the German space agency to allow the Woomera range to be the recovery site for a satellite from the German Express satellite programme by August 1994.

In the longer term the German space programme could be interested in upgrading the Woomera launch site for launching low-orbiting or light-weight satellites. The South Australian state government has lodged a bid to have Woomera used as the landing site for a Russian-built space capsule to be launched in 1994. Woomera, which is about 600 km (370 miles) north of Adelaide, was the launch site for more than 4,000 rockets during joint Australian-British operations in the 1950s and 1960s. There has been little activity at the site since the early 1970s.

Mir Collision

A slight collision occurred between the Mir space station and the departing Soyuz TM-17 after undocking on 14 January. The causes and consequences are uncertain. The work plan to be undertaken by cosmonauts Viktor Afanasyev, Yuri Usachev and Valery Polyakov, now aboard Mir, does not provide for space walks, but one or more may now be necessary.

The Soyuz-17 descent module carrying Vasily Tsbiliev and Alexandr Serebrov touched down at 11:18 am on 14 January after the two cosmonauts had spent 197 days aboard the Mir orbiting space station. During their time in orbit they made five space walks totalling 14 hours and fitted additional equipment to the Russian-built space station.

Cosmonaut Alexander Serebrov broke the world record for spacewalks on 22 October 1993, becoming the first man ever to venture outside an orbiting spacecraft nine times. He and fellow cosmonaut Vasily Tsibliyev left the Mir space station to check on equipment for testing special materials in space. They returned 38 minutes later. The walk was to have lasted nearly five hours, but the cosmonauts finished the work early. The two cosmonauts had been in orbit since July 1993. Soviet cosmonauts Leonid Kizim and Vladimir Solovyov set the previous record of eight spacewalks in 1986.

Asteroid Rendezvous

The Near Earth Asteroid Rendezvous (NEAR) mission will be launched in 1996 on a three-year journey to the asteroid Eros and then spend another year orbiting the asteroid. In 1975, Eros passed within 14 million miles of the Earth.

Johns Hopkins University will conduct the mission operations from its campus near Laurel, Md. The flight will be the first mission conducted by a non-NASA space centre. It will also mark the debut of NASA's low-budget Discovery programme, which aims at small-scale, cost effective space exploration (see ***Spaceflight***, July 1992, p.222 and May 1993, p.151).

Launch Setback for Ariane

Failure after 26 Successes

Flight 63 of an Ariane 44L failed on the night of January 24 when an oxygen turbo-pump in the rocket's third-stage malfunctioned about seven minutes after lift-off. Turkey's first telecommunications satellite Turksat 1A, and a European telecoms satellite, Eutelsat 2-F5, fell into the ocean 1,200 km off the coast of Africa. Failures of the third stage, which uses both liquid oxygen and liquid hydrogen, plagued early Ariane launches but have not been responsible for a failure since flight 18 in 1986. Both lost satellites were built by Aerospatiale and covered by insurance.

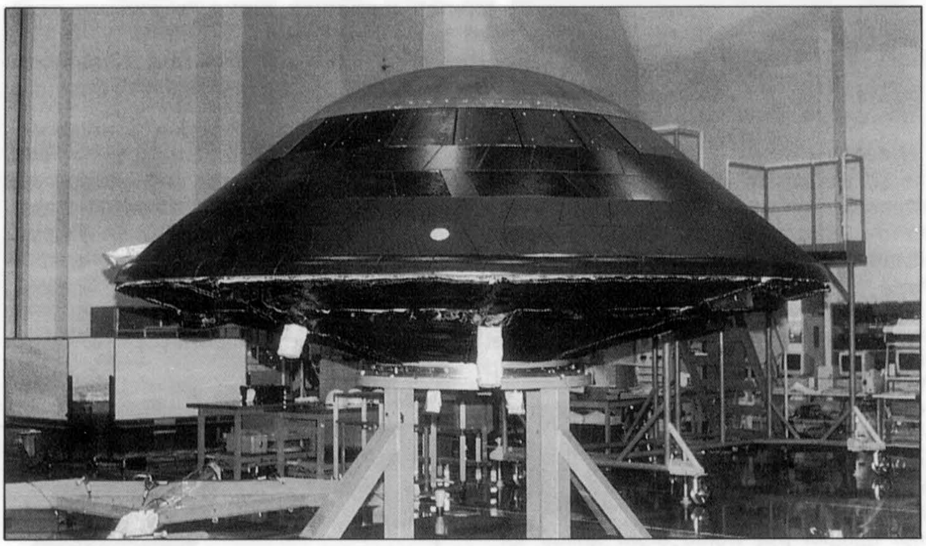
All-Japan Rocket Success

Watched by thousands, the first all-Japanese launcher rocket, the H-2, blasted off from the Tanegashima Space Centre in southern Japan on 4 February and reached orbit.

Some 14 minutes after launch the H-2 released an orbital re-entry experiment vehicle, known as OREX, into one orbit around the Earth at an altitude of 450 km. Another 28 minutes into flight, the H-2 sent a 2.4 tonne satellite, known as a vehicle evaluation payload (VEP), into a high-altitude orbit to circle the Earth for four days. Two hours after lift-off, OREX splashed down as planned 460 km south of Christmas Island in the Pacific. On re-entering the atmosphere, OREX conducted various tests that will help in research and development of a future unmanned space shuttle called HOPE, expected to be launched around 2005.

Above: Artist's impression of an H-2 launch. The vehicle is a two-stage rocket equipped with two large solid rocket boosters. NASDA

Below: Orbital Re-entry Experiment (OREX) vehicle (3.4 m outer diameter, 1.46 m high) which simulates the structure of the nose portion of a winged space transportation vehicle. It is here being serviced at the launch site in preparation for its forthcoming launch. It is used to acquire data related to structural materials and designs which resist high temperature when it re-enters the atmosphere from orbit. NASDA



Moon Mission Underway

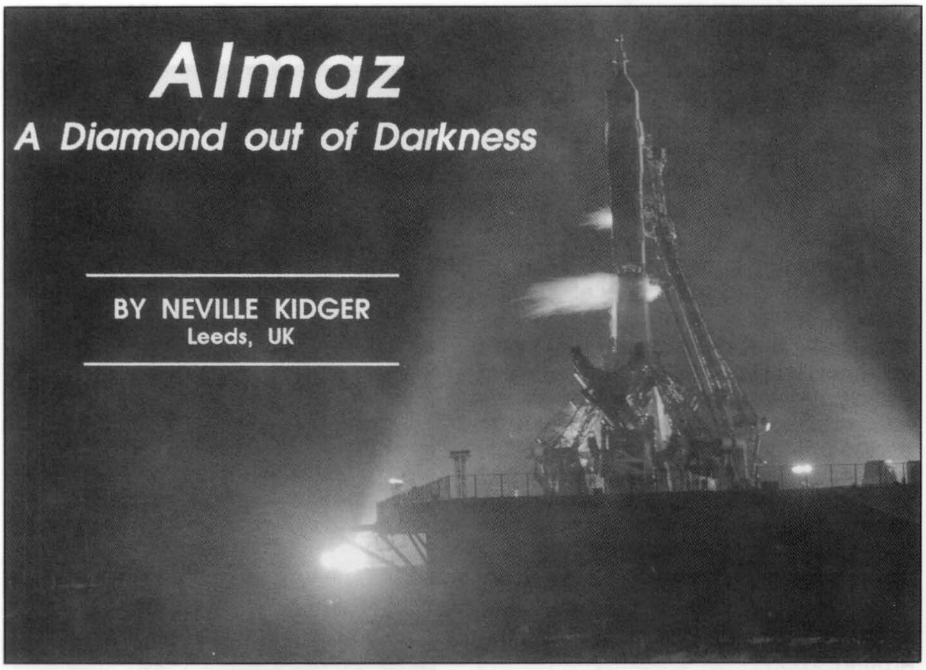
The 933-pound, 6-foot spacecraft Clementine 1 lifted off aboard a Titan 2 rocket on 25 January for the first US lunar exploration since the last Apollo flight in 1972 (*Spaceflight*, July 1993, p.245).

The spacecraft's primary mission is to test five miniature "Star Wars" sensors designed to detect and track missiles.

After systems checks in Earth orbit it is due to enter the Moon's orbit later this month and for two months will map its entire surface in visible and near-infrared light. Then it will focus its sensors on the asteroid Geographos, passing within 75 miles of it on August 31 1994.

On 3 February a new technology developed by TiNi Alloy Company, a small R&D firm in the San Francisco Bay area, enabled the spacecraft to successfully deploy its solar panels. The device, called Frangibolt, comprising a commercially available bolt and a small collar made from a unique shape-changing metal, was heated by a heater coil to trigger a change in the collar's shape, elongate the material and exert over 5,000 pounds of force to break a restraining bolt and free the solar panels.

On the same day, the solid rocket motor was successfully fired and boosted the spacecraft on its way to the Moon.



A night-time Soyuz launch from Baikonur.

Between 1973 and 1977 the Soviet Union undertook the launch of three Salyut space stations whose operations became known in the West as "The Soviet Manned Military Space Station". Whilst civilian versions of the Salyut stations received great publicity and propaganda, the military stations were clouded in secrecy.

Only in recent times have significant details been forthcoming from Soviet and Russian sources regarding the history and operation of these secret outposts in space. The veil of darkness was lifted still further during a 1992 visit to Yorkshire of one of the central characters in the programme - Cosmonaut Number 49, Colonel Mikhail Ivanovich Lisun, a military engineer who remained in the cosmonaut team between 1965 and 1989. During his stay *Neville Kidger* had the opportunity to chat with him and learn some intriguing new details regarding the military space station programme, which the Soviets knew as "Almaz" ("Diamond").

History

According to Soviet sources, the Almaz programme had its roots in the mid-1960s decision of the United States to construct a manned military space station (MOL). The Chelomei design bureau (OKB-52) was chosen to design, develop and launch a Soviet version, known as the Orbital Piloted Station (OPS).

Initially, the Almaz programme envisaged two separate components - the Almaz station itself with a recoverable manned capsule and a ferry ship of a similar size and weight, known as the TKS, which also featured a recoverable (three-man) capsule. Due to design changes and operational needs, the Almaz station lost its capsule, whereas the TKS retained its descent capsule throughout the programme. Both the Almaz station and the TKS were to be launched by the UR500K Proton carrier rocket, developed by the Chelomei Bureau.

The Almaz station was 14.55 m in length with a maximum diameter of 4.15 m. The TKS was the same diameter but was 17.51 m in length including the manned capsule. The TKS was to be manned at launch with the cosmonauts sitting in the descent cabin (called "Merkur") for ascent and then moving into the interior of the TKS through one of three hatches on the cabin in the base of the descent cabin. For docking the TKS with Almaz, Mikhail Lisun said that the cosmonauts sat facing forward, looking through windows in front of them as distinct from the periscope arrangement used by the Soyuz spacecraft.

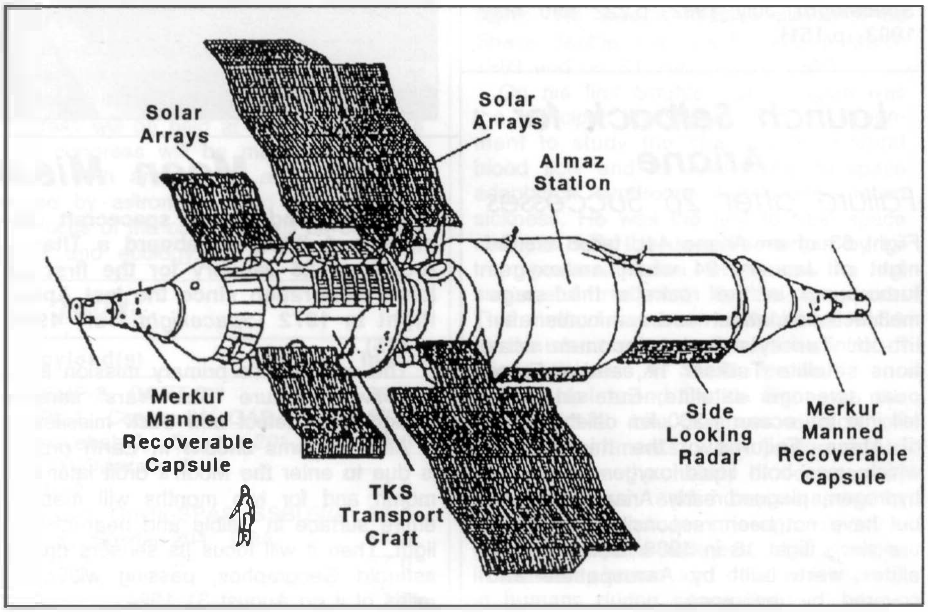
The Cosmonaut Training Centre teams were split into different programmes and Lisun found himself in the Almaz programme. Original plans called for a crew of three persons to undertake extended flights on the OPS. He trained in both TKS and Soyuz spacecraft in preparation for a flight to Almaz before the Soyuz was chosen to be the actual ferry ship after intense political in-fighting between the Chelomei and Korolev Bureaux.

The Chelomei bureau unilaterally chose some of its own engineers to train on TKS, the first selection consisting of three engineers - V. Makrushin, D. Yuyukov and A. Grechanik. In 1973 a second selection saw engineers V. Romanov, V. Gregorkyan and V. Khatulev join the group. However, the six engineers were "illegal" cosmonauts, according to Lisun. He stated that the Chelomei engineers were not granted cosmonaut status until 1980, some three years after the end of the flight of the third Almaz station.

The first Almaz station was ready to fly in 1969 according to Lisun. An article in *Rossiyskiye Vesti* claims that by 1970 there were 10 "virtually ready" Almazes at the Krunichev assembly plant near Moscow. But then came the first major setback to the programme. With the Soviets losing the race to the Moon, Lisun said that the Brezhnev government decreed that the Korolev bureau - permanently at odds with Chelomei's - should develop a long-term orbital station (DOS).

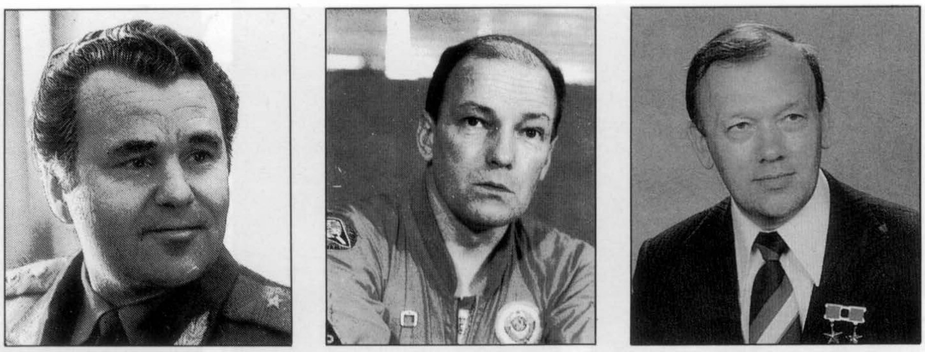
In order to do this expediently the Korolev bureau (known today as NPO Energiya) used documentation from Almaz's creators, took the exterior design of the OPS, a stepped cylinder, and fitted out the interior with the controls of their Soyuz ferry ship. (A recent article hints that this had a

Original design of the Almaz station. © ZNANYE 1991



profound effect upon the morale of the Chelomei designers).

A Soyuz spacecraft engine was located at the rear of the Korolev station (what was previously the docking end of Almaz) and a docking and transfer section was added at the opposite end, where the recoverable capsule had been located, for the docking of the Soyuz. The two elegant solar arrays of the OPS were replaced by four arrays taken, again, from the Soyuz spacecraft.



From left to right: V.A. Shatalov, N. Rukavishnikov and A. Yeliseyev, the three man crew of Soyuz 10 that docked with Salyut 1 on April 23, 1971.

Salyut 1

The first of the Korolev stations - Salyut 1 - was launched on April 19, 1971. Salyut 1 was so named just an hour prior to launch when it was discovered that the original name of "Zarya" was also that of the ground control stations. A three-man crew of Shatalov, Yeliseyev and Rukavishnikov soft-docked with Salyut 1 in Soyuz 10 on April 23, 1971 but because of the failure of a "weak" docking unit, the men were unable to cross over into the station and they returned home after just two days in space.

On June 6, 1971 the crew of Dobrovolski, Patsayev and Volkov were launched in Soyuz 11. They docked with Salyut the next day and spent 23 days aboard before being ordered back to Earth. During their time in space, they saw and photographed the explosion of the third flight version of the N-1 lunar lander on 27 June 1971.

Tragically the three men perished when their craft depressurised after the separation of its three separate modules. They had no pressure suits aboard because of the decision taken years before to fly without them. Recently released film of the recovery shows doctors frantically administering heart massage and mouth-to-mouth resuscitation in a vain attempt to revive the dead cosmonauts. Even chief designer Vasili Mishin, then head of the Korolev bureau, admits that, had the cosmonauts trained for such an event, they could have plugged the 1 millimetre vent where the air escaped with a finger.

The catastrophe meant a return to the wearing of pressure suits for launch and entry, but with a cost. The Soyuz could now only carry two men and was stripped of its solar panels meaning an autonomous lifetime in orbit of just two days.

The second Korolev bureau station was launched on July 29, 1972 but, following a fault in the second stage of the Proton carrier rocket, it was lost without achieving orbit. With the civilian DOS stations grounded for another year the next attempt to place a station in orbit would fall to the Chelomei bureau's OPS.

Salyut 2

Following a three-month checkout and preparation, the first OPS Almaz station was launched on April 3, 1973. Built by the Krunichev factory in Moscow, the station was designated Salyut 2 once safely in orbit. The first crew were to have been Pavel Popovich and Yuri Artyukhin. They were preparing for their launch at Baikonur when the OPS programme received another setback.

Lisun said that an electrical fault in one of the station's devices resulted in a fire which eventually caused the rupture of the external hull and the depressurisation of the Salyut 2 station. (One report says the fire originated in the station's engine unit). Had Popovich and Artyukhin been on board the station at the time, Lisun said, they could have taken flight to their Soyuz ferry and sealed themselves in. The Sokol ascent-and-entry pressure suit can be donned in just 90 seconds, Lisun said.

Salyut 3

The first successful Almaz station was known as Salyut 3 after being placed in orbit on June 24, 1974. Cosmonauts Popovich and Artyukhin completed a 14 day mission on the station in July.

The next pair of military cosmonauts - Gennadi Sarafanov and Lev Demin - were unable to dock their Soyuz 15 craft with the Salyut 3 station in August due to a fault in the approach systems of the Soyuz spacecraft.

The Almaz stations carried a recoverable capsule, located under the docking port, which was used for the return to Earth of films. The Salyut 3 capsule was ejected and returned to Earth, parachuting to a soft landing, before the station itself was commanded to destruction on January 24, 1975.

Salyut 5

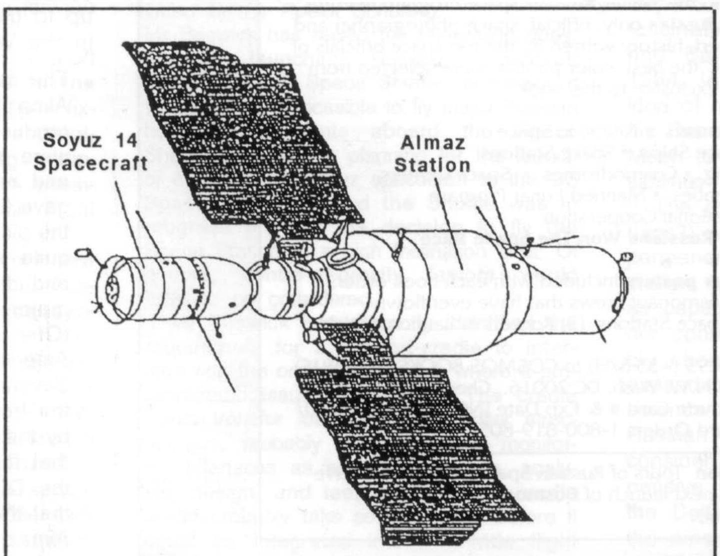
The third Almaz station was launched on June 22, 1976. The first crew consisted of Boris Volynov and Vitali Zholobov and the flight was planned to last for two months. However, due to a gradually worsening illness suffered by Zholobov, the flight was cut short after 49 days.

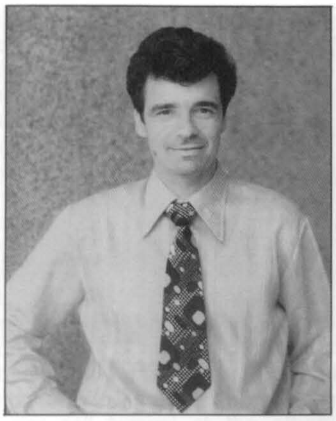
Mikhail Lisun was drafted into the flight preparations for the next mission as flight engineer for the third crew, commanded by Anatoli Berezovoi.

In October, Vyacheslav Zudov and Valeri Rozhdestvenski were unable to dock with Salyut 5 due to a fault with the antenna of the main guidance system and they spent an uncomfortable night in their recovery capsule after it splashed down in frozen Lake Tenzig. Recovery personnel were surprised to find the men alive in the capsule.

After the failure of this mission it was planned to fly an extra mission to Salyut 5. Viktor Gorbatko and Yuri Glazkov were selected for an 18-day flight in February 1977 and their reserves Berezovoi and Lisun were slated for the following flight. The reserve crew for Berezovoi and Lisun was Vladimir Kozelski and Vladimir Preobrazhenski.

Salyut 3 space station (OPS-2 Almaz). **© ZNANYE 1991**






V. Zudov and V. Rozhdestvenski who failed to dock with Salyut 5 in October 1976.


V. Gorbatko and Y. Glazkov who flew to Salyut 5 in February 1977.

Why no Flight for Lisun?

Lisun wistfully described seeing the carrier rocket which took Gorbatko and Glazkov into space on the launch pad before the two reserve cosmonauts headed underground into a bunker. When they emerged the rocket had gone and all that remained was the boundless steppe. This left a deep impression on Lisun.

The Almaz cosmonauts worked long days in space. Indeed, Lisun stated that the demands on the crew of Gorbatko and Glazkov, who flew for almost 18 days, were as great as those on Klimuk and Sevastyanov who flew for 63 days in 1975.

Before returning to Earth, Gorbatko and Glazkov loaded up results of their work into the return capsule which subsequently returned automatically to the Earth (later to be sold at auction along with the "Merkur" capsule from the unmanned TKS Kosmos 1443 on December 11, 1993 in New York!).

During the mission of Gorbatko and Glazkov, cosmonauts Berezovoi and Lisun were working in the ground-based Almaz simulator trouble-shooting any problems encountered by the two men in space.

Following the return of the Soyuz 24 crew, Berezovoi and Lisun were told to prepare for their mission. The launch of their Soyuz - Number 25 - was scheduled for March 1977. Lisun recalled a meeting at which the cosmonauts were present, along with the head of the training programme, Vladimir Shatalov, and the designers. Valentin Glushko, by now the head of the Korolev bureau, told the meeting that he would need two months to build and test the extra Soyuz spacecraft for the flight of Berezovoi and Lisun. He then needed another two months to get the craft to Tyuratam and prepare and launch it.

During its period of unmanned flight, the OPS Almaz had to be permanently oriented towards the Earth, requiring the use of precious fuel reserves. After calculations had been completed it was realised that by the time the extra Soyuz ship was ready for launch the station's fuel reserves would be 70 kg lower than that required to complete the planned 15 day mission.

Colonel Lisun seemed philosophical that his chance to fly rested upon a shortage of fuel now that stations can be automatically refuelled time and again by unmanned freighters. He provided the writer with brief details of some of the aspects of the station that, up to then, had only been speculation in the West:

- The camera system used on the OPS Almaz had a six metre focal length and produced pictures of 50 x 50 cm which were developed on board the station and relayed to Earth. The cosmonaut gave the writer no actual resolutions for the pictures but said that on them it was quite easy to make out an aeroplane and identify the type. Lisun said that the major targets were US naval bases. (One article specifically mentions the American Seventh Fleet).
- Several contemporary reports detailed the training for EVAs to be undertaken by the cosmonauts and it was assumed that these related to Almaz as well as the DOS Salyut. However, Lisun said that there were no plans for EVAs from Almaz, in fact Almaz did not carry EVA suits.

- Although there were plans to equip the Almaz station with an aviation rapid-fire cannon designed by the bureau headed by Nudel'man, Lisun vehemently denied that the Almaz stations in space carried such a weapon.

Almaz Termination

There were plans to launch an improved Almaz station in the 1979-1980 time period with a weight of 35 t and with two docking ports - one each for the TKS and Soyuz ships - following the development of a new carrier rocket. The plans were, however, scrapped for lack of funds and the Almaz programme closed in 1978.

Earlier in 1978 the following group of engineers had been selected for training on the TKS/Almaz: S. Kondratyev, B. Morozob, L. Tararin, S. Chelomei, A. Chekh and S. Chuchin.

The Almaz programme was terminated in 1980.

Unmanned Almaz Stations

With the cancellation of the manned OPS Almaz station, the programme was moved into an unmanned stage with the large station carrying a side-imaging radar. Despite the flight version of the first radar-equipped Almaz station being at Baikonur from 1981, the station was not launched until 1985 because of a serious dispute between the Soviet defence minister Ustinov and Academician Chelomei.

The launch of the Almaz in 1985 failed because of a fault in the control system of the Proton carrier rocket.

The first unmanned Almaz station to achieve orbit was known as Kosmos 1870 and it operated from July 18, 1987 to July 30, 1989 returning images of Earth with a 10-15 metre resolution.

The first station to be given the Almaz name was launched on March 31, 1991 and operated until October 17, 1992 returning images which were marketed commercially around the world.

Current Status of Mikhail Lisun

Following the disbandment of the Almaz cosmonaut teams, Colonel Lisun was given the job at the Flight Control Centre of Chief Operator for the InterKosmos manned missions and was identified in 1982 by French journalists as an unflown cosmonaut.

Later he spent 90 days in the ground version of the Kvant-2 module to test its systems. The module was launched in 1989 to dock with the Mir station.

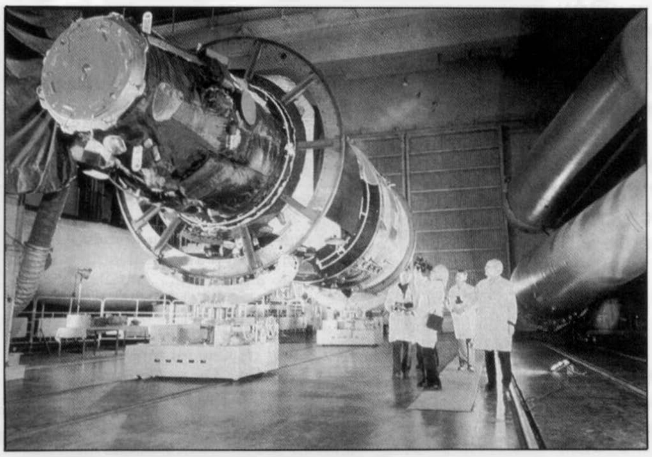
Lisun left the cosmonaut team in 1989 to become the Director of the Sergei Korolev House Museum and Deputy Director of the Memorial Space Museum in Moscow.

Acknowledgements

The writer would like to express thanks to Rex Hall, to Ralph Gibbons for his superb translation of "Unknown Spacecraft" by I.B. Afanasyev in *Znanya*, December 1991 and Phillip Clark for providing background information regarding the Almaz programme. Special thanks to Olga for translations. ■

New Facts about Soviet Space Stations

In a recent publication, a historical review appears of Soviet space stations writes *Dr H. Pauw* of the Netherlands. The publication is Cosmonautics 1991 by Y. Semenov *et al*, issued by Mashinostroenie Press, CIS and Matson Press, USA, (1992) and Dr Pauw provides the following summary for *Spaceflight*.



Assembly and testing of the Salyut-7 orbital station.

BY H. PAUW
The Netherlands

The Almaz space station was designed for a one-year operational period and was intended to be launched with cosmonauts onboard. It incorporated a totally new recoverable capsule (***Spaceflight***, September 1992, p.292) and had sophisticated instruments with which to study the Earth's surface, including the oceans.

The initial go-ahead was given in 1965 and entrusted to the OKB, headed by Chelomei. Two cosmonauts were needed to operate the station and test flights should have started in 1968. However, technical problems delayed the Almaz project for several years and the intention to launch Almaz before the US Skylab was clearly not going to be realised. As the Soviet leadership could not allow this to happen, they ordered work to be stepped up on the development of another manned space station at Korolev's OKB.

This work was a similar project, called DOC-7K, and was based on the Soyuz spacecraft which had passed flight tests and utilised individual units of the Almaz station. The DOC-7K station would be launched unmanned and manned at a later date, using the Soyuz spacecraft as a transfer vehicle. In February 1970 the work was entrusted to the OKB, headed by Mishin, Korolev's successor.

The actual construction of the DOC-7K station was entrusted to the Khrunichev enterprise, which had already been engaged for a number of years in the assembly of the Almaz station. However, parallel production was impossible and the assembly of the Almaz station was suspended in favour of the DOC-7K station. But in subsequent years the Khrunichev enterprise managed to manufacture both the DOC-7K and the Almaz station, as well as a recoverable vehicle.

At the end of 1972 the third DOC-7K station and the first Almaz station were both ready to be launched. The decision on which one to launch first was taken personally by Brezhnev. The Almaz station turned out to be the winner, mostly due to the two unsuccessful flights of the DOC-7K station. The design of the Almaz station had changed drastically from the early concept. The return vehicle had been discarded and the cosmonauts were flown to the station by the Soyuz spacecraft.

The following table summarises the launches that took place. ■

Project		Launch date	Name after launch
DOC-7K	(No.1)	April 19, 1971	Salyut-1
DOC-7K	(No.2)	July 29, 1972	Launch failure
Almaz	(No.1)	April 3, 1973	Salyut-2
DOC-7K	(No.3)	May 11, 1973	Cosmos-557
Almaz	(No.2)	June 25, 1974	Salyut-3
DOC-7K	(No.4)	December 26, 1974	Salyut-4
Almaz	(No.3)	June 22, 1976	Salyut-5
DOC-7K	(No.5)	September 29, 1977	Salyut-6
DOC-7K	(No.6)	April 19, 1982	Salyut-7

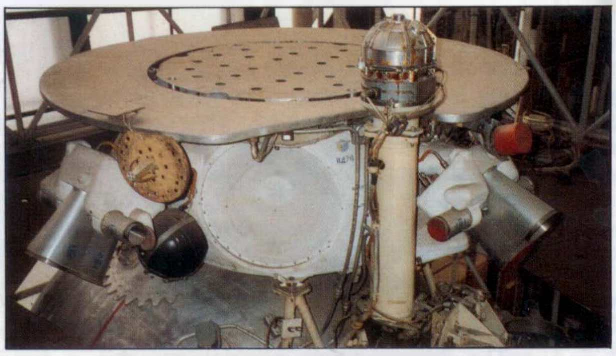
Soviet Lunar Landing Programme

A Closeup of LK, the Manned Lunar Lander

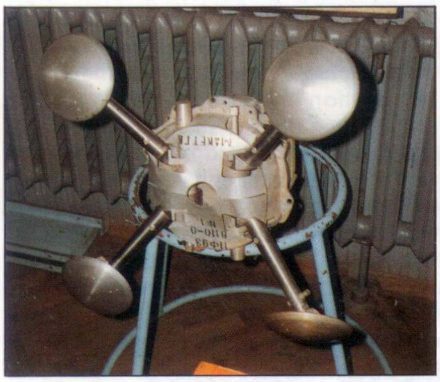
BY LUC VAN DEN ABEELEN
Fellow BIS

Since the revelation of the Soviet lunar lander to Westerners at the end of 1989, an increasing amount of information on the lunar programme hardware has been forthcoming. Recently, the author visited the Moscow Aviation Institute (MAI) and inspected the manned lunar lander (Lunniy Korabl, LK). It is one of the four complete landers (production designation 11F94) known to have been constructed, the others residing in the Kaliningrad Technical Institute, the Mozhaisk Military Institute in St Petersburg [1] and NPO Yuzhnoye, Dnyeprpetrovsk.

At the top of the LK is the passive part of the 'Kontakt' docking system, which consists of a circular plate, some 100 cm across, containing 108 recessed hexagons, about 6 cm in diameter, in a honeycomb pattern. These hexagons were to receive the active part of Kontakt, i.e. the docking probe on the Lunar Soyuz (Lunniy Orbitalniy Korabl, LOK or 11F93). This design allowed successful docking manoeuvres with poor precision, probably dictated by a lack of high quality rendezvous equipment.



The MAI LK orientation module with docking plate, thruster units and communications antennae.



Active part of 'Kontakt' docking system (without probe).

The active part of Kontakt is exhibited at MAI, but its docking probe is missing. In flight, the active Kontakt would have been installed on top of the orientation module on the Orbital Module of the LOK. This module is also exhibited at MAI [2] and is shown in the diagram below. Whether or not it was used as a separate module remains unclear as Soviet drawings show only part of this module on the LOK [3]. This seems to suggest that either only the top half was used, installed on the LOK OM, or that the module was carried half inside, half outside the OM.

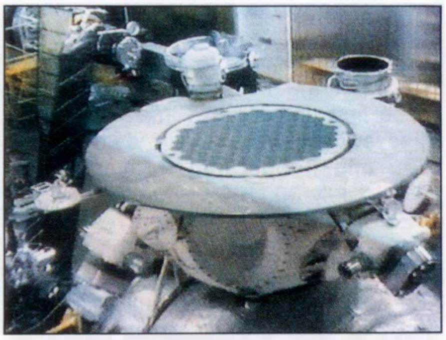
A ring around the docking plate protects equipment of the orientation module from coming into contact with the docking probe during possible unsuccessful docking attempts. This module is equipped with 4 units of attitude control thrusters, fuel tanks and antennae. Each thruster unit contains two main nozzles, firing 45 degrees downwards, and two smaller ones, firing sideways at 90 degrees to the main ones. Near each thruster unit, a circular combined telemetry-TV antenna is installed, while a fifth one points upward alongside the protective ring. There is a cutout in the ring to give room to a chimney-like structure, installed on top of the cabin. It carries a rendezvous antenna.

The docking plate on the LK at MAI is most probably not original. It looks newer than the rest of the vehicle and does not have the six-sided receptacles. Instead, 28 holes are distributed over the plate. The 'hexagon-version' is installed on the lander at St Petersburg [4].

The cabin appears to be based on the Soyuz Orbital Module, but it is shorter and spherical. It contains a standard Soyuz hatch with an external handle turned clockwise to open, anti-clockwise to close. Two small attitude control thrusters are found next to the hatch, similar to early Soyuz. The St Petersburg version seems to exhibit a small TV camera just over the hatch, pointing downwards.

Conspicuous by their absence are any handrails for use by the cosmonaut during his EVA from LK to LOK. They do not appear on any of the four known landers. If the side with the hatch is taken as the front, the left part of the cabin is part of a sphere of smaller diameter, with a dome-shaped recess, containing the viewport. On the right side of the cabin is a short cylindrical part, closed off by a dome.

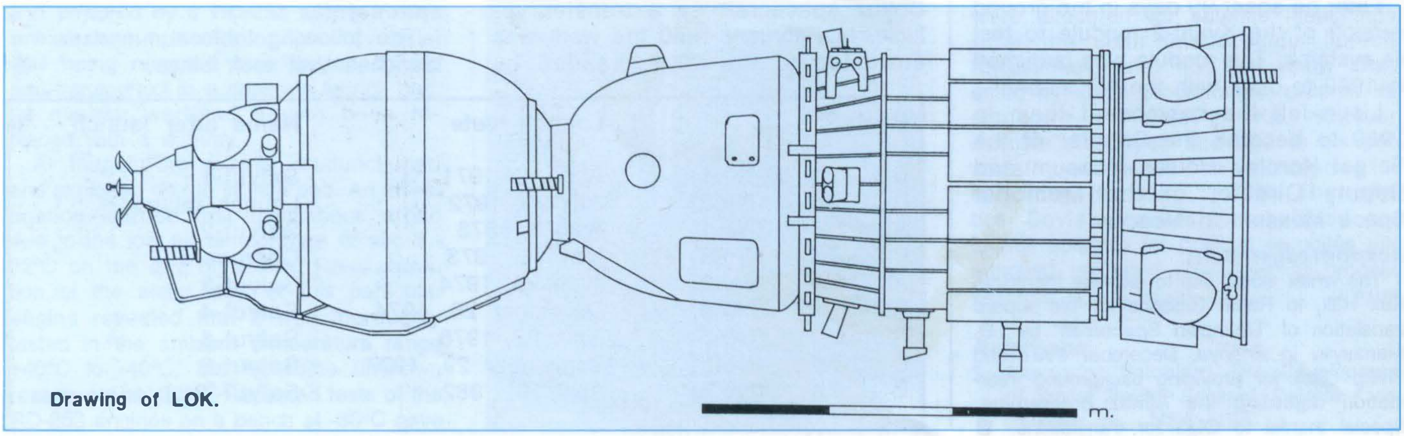
On the MAI-version of LK, there is a small conical structure on this dome, which is missing from the lander in St Petersburg.



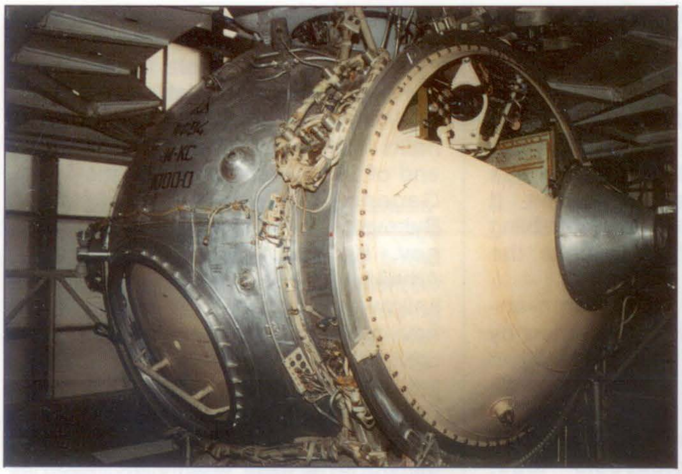
'Kontakt' docking plate on LK. MOSCOW TV

The cabin is highly asymmetrical, much more so than the American LEM, and, with the hatch situated out-of-centre, it gives the Soviet lunar lander an awkward appearance. Omnidirectional antennae are installed on the front and back of the cabin.

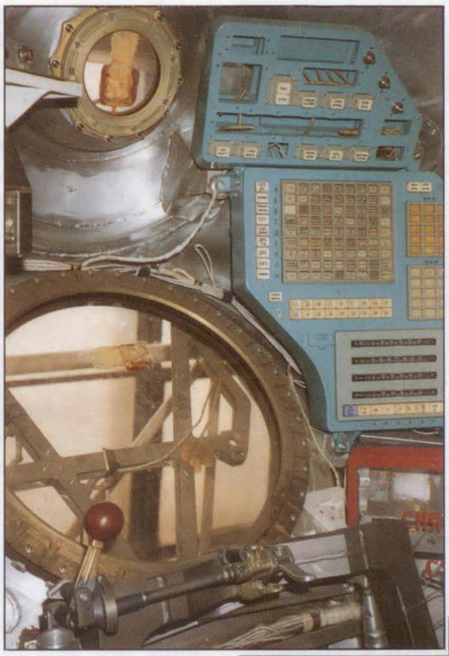
Continued on page 92.



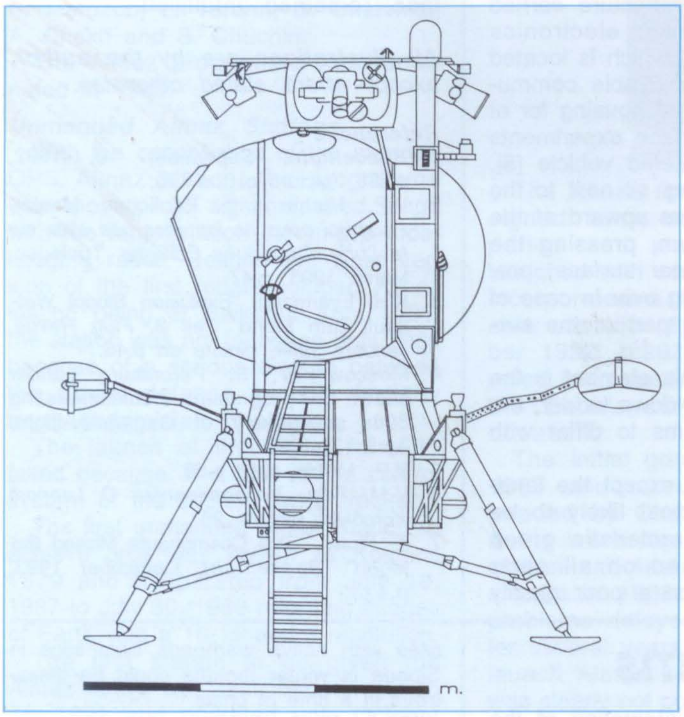
Drawing of LOK.



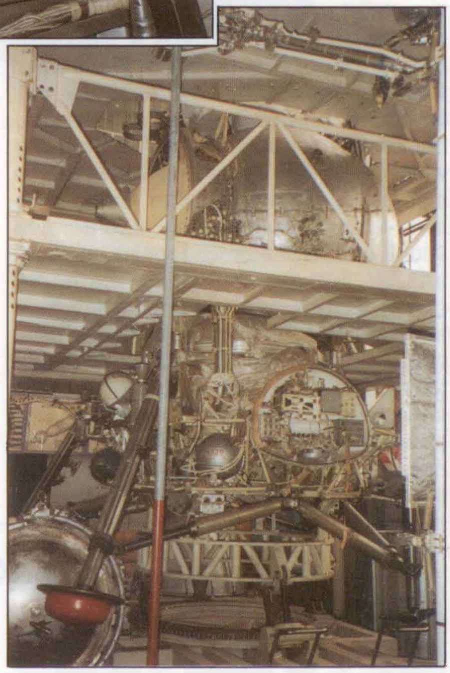
The MAI LK cabin. (Compare with ref. 1).



MAI LK Interior view.

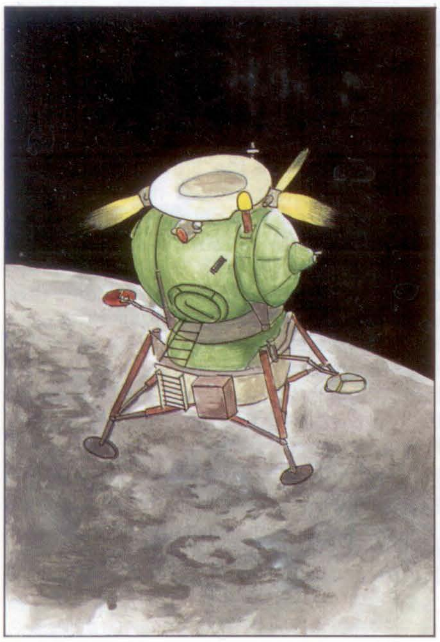


A drawing of the LK by the author. The vehicle is approximately 5.2 m high and weighs 5.5 t.

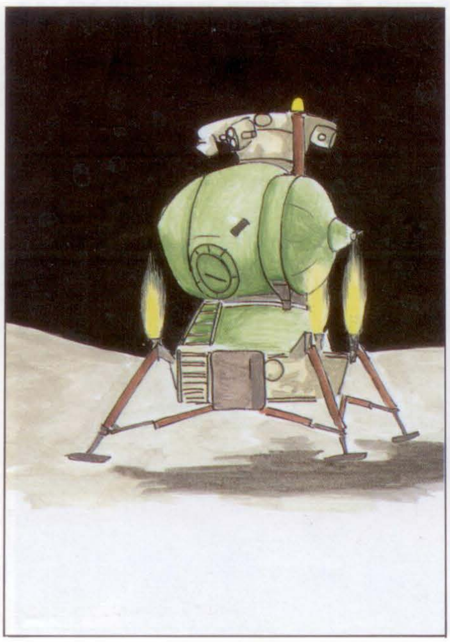


MAI LK Rear view.

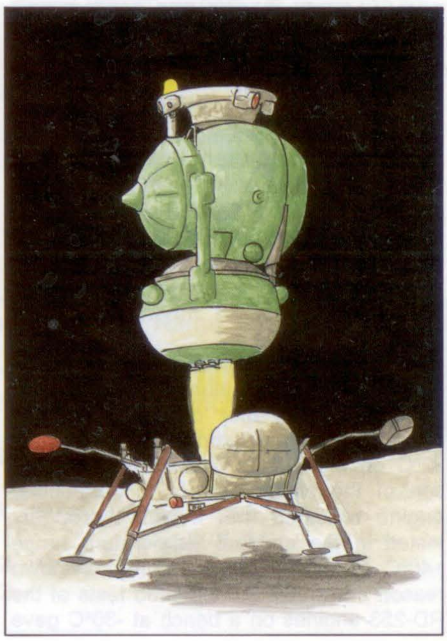
LK thruster firing during descent.

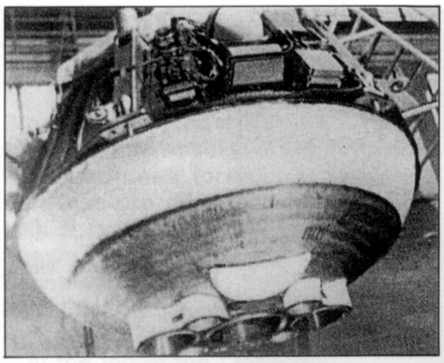


LK engine firing at moment of touchdown.



LK engine firing during liftoff of cabin.





Engine block of LK.
VOSPOMINANIYA O LUNNOM KORABLYE

The interior of the cabin is very cramped. Equipment seems to be installed at every available spot. Foot restraints and braces which connected to the cosmonaut's lunar 'Krechet' (Gyrfalcon) EVA suit would hold him in place during the descent to the lunar surface. A Krechet suit was presented at the Sotheby's Russian Space History auction in December 1993. An interesting feature of the suit is that it introduced the side-hinged backpack, functioning as a door by which to enter. This design feature is still used in the Russian Orlan-type suits and is likely to be incorporated into future US and European spacesuits.

A U-shaped support on the left side and two beams on the right attach the cabin to the engine block which contains fuel tanks and engines. There is one main, single-nozzle engine, one backup two-nozzle engine, and 4 verniers. The engine nozzles can be protected by closing two small doors, presumably to prevent ingestion of possible debris generated by LK-Block D staging or lunar material during the cosmonaut's EVA.

The upper part of the exterior of the engine compartment is covered with small gas tanks, electronics boxes and other unidentified equipment. It also carries part of the ladder enabling the cosmonaut to step down to the lunar surface.

The orientation module-cabin-engine block combination was carried by the landing structure, made up of two rings of beams, connected by X-shaped girders and a metal conical wall on the inside. Installed on it were four retractable telescopic legs, measuring some 6.3 m across in extended position. The structure carried more small gas tanks, electronics boxes, a large one of which is located on the back, two deployable communications antennae, and housing for at least two sets of surface experiments and a small four-wheeled vehicle [5]. Four solid fuel engines sit next to the legs. They were to fire upward at the moment of touchdown, pressing the vehicle on to the lunar surface, preventing it from toppling over in case of landing on a sloping part of the surface.

Also installed on this element is the larger part of the fold-down ladder, the design of which seems to differ with each lander version.

The entire vehicle, except the landing structure, was most likely to be covered in the characteristic green thermal blanket, used on all early Soyuz. It is visible on a poor quality picture of Object T2K [6]. These were stripped down versions of the lander without legs, which were launched into Earth orbit for test missions [7].

In the end, none of the 18 cosmonauts training for lunar missions at the end of 1968 ever made it to the Moon. Gagarin, Komarov, Nikolayev, Bykovsky, Khrunov, Gorbatko, Voronov, Kolodin, Popovich, Gubarev, Artyukhin, Gylyayev, Belousov, Kolesnikov, Volynov, Dobrovolsky, Voronov and Zhobolov flew only in Earth orbit or never went into space at all.

Command number 655-268 of the Central Committee of the Communist Party, passed on August 3, 1964, aiming for a flight around the Moon by a cosmonaut and a landing on its surface, remained unfulfilled.

All illustrations are by the author, except where stated otherwise.

References

1. ***Spaceflight***, September 19, 1992, p.288, (picture of the LK).
2. V.P. Mishin with Pouliquen Marcel, *Pourquoi nous ne sommes pas allés sur la Lune*, Cépaduès Editions, Toulouse, March 1993, p.47.
3. K.H. Eyermann, "Explosion Stoppt Wettlauf Zum Mond" Teil 2, *Flug Revue*, January 1994, picture on p.45.
4. Moscow TV, St· Petersburg Lander shown in programme commemorating 30th anniversary of Gagarin's flight, April 12, 1991.
5. V.P. Mishin, *ibid.* p.53.
6. V.M. Filin, *Vospominaniya O Lunnom Koroblye*, picture 26.
7. T. Pirard, "The Cosmonauts Missed the Moon", ***Spaceflight***, December 1993, p.413.

Soviet Rocket Problems

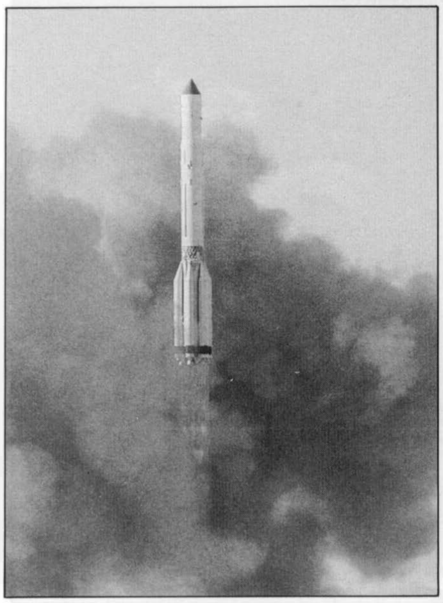
One of the serious problems to be solved in the development of rocket engines is the problem of oscillations in the feed lines of the liquid propellants [1]. Such oscillations occur randomly, even in engines tested and produced for many years, and cause disintegration of the engine or explosion of the rocket.

In the winter of 1965-66, an accident took place which almost paralysed the Soviet nuclear missile system. An operational ICBM, developed by Yangel's OKB and powered by a RD-253 engine (which is also used in the Proton launch vehicle) was being removed from its launch silo and transported to a separate launch pad, its nuclear warhead having been replaced with a dummy.

At launch the missile malfunctioned and exploded on the launch pad. An investigation learned that oscillations arose due to the low air temperature of about -32°C on the day of launch. Re-examination of the static tests of this particular engine revealed that it was thoroughly tested in the ambient temperature range +40°C to -40°C, but for some unknown reason not at -30°C. Repeated tests of the RD-253 engines on a bench at -30°C gave the same results: disintegration of the engines due to oscillations.

The Soviet leadership immediately realised that launching operational missiles with active warheads from silos in Siberia in winter months could be disastrous in a time of crisis.

Blastoff of the Proton booster rocket.
GLAVKOSMOS



The oscillation problem was temporarily solved by spraying a layer of iridium onto the inner surface of the engine nozzle. This was done by means of a plasma device, directly inside the launch silo and without removing the engine from the operational missile.

In the same publication, several problems of the Soviet rocket industry are described in great detail and some interesting information is given on the pre-Sputnik period. At the time that Korolev's OKB was founded seven military rockets were allocated for satellite launchings. After the sixth unsuccessful launch, Khrushchev, who was not really interested in space programmes, ordered the shutdown of Korolev's OKB. However, Korolev disobeyed and due to his personal persistence he succeeded in launching the first Sputnik. Thereafter the Soviet leadership exploited the launch success for political purposes and supplied unlimited resources to proceed with the space race.

H. PAUW

Reference

1. Alexander Bolonkin, *The Development of Soviet Rocket Engines*, Delphic Associations, Inc., USA (1991).

Shuttle Role for Mir Modules

Sir, Following the recent, triumphantly successful STS-61 mission to repair and service the Hubble Space Telescope, there appears to be the possibility of an 'empty slot' in the STS payload manifest for 1994 which was tentatively reserved for a back-up HST-servicing mission had Endeavour's crew been unable to complete their task. May I make a suggestion as to how to profitably fill that empty flight opportunity?

The Russian Space Agency is currently still waiting to launch its final two dedicated 'building block' modules 'Spektr' and 'Priroda' to the Mir complex. The masses and dimensions of both these modules make either one of them suitable for launch and orbital delivery by the US Space Shuttle. Were such a joint operation to be approved, the module's mass could be reduced by deletion of propellant and associated hardware for on-orbit rendezvous and docking with Mir as hitherto envisaged. The module would also (probably) have to be rendered (at least temporarily) electronically-inert.

I envisage a rendezvous and station-keeping with the Mir complex by the Space Shuttle. Docking would not be required and (probably) would not be possible given the fact that the Russian-made joint docking adaptor is currently undergoing fit-and-test assessment in preparation for the planned 1995 docking of 'Atlantis' with Mir. The latter mission could, nonetheless, benefit from in-flight experience gained in rendezvous and station-keeping under the proposed mission.

Transfer of the modules is envisaged by the Shuttle's RMS 'robot arm' lifting it out of the shuttle payload bay. The 'Lyappa' mobile fulcrum mounted on Mir's multiple docking hub would then engage the corresponding socket on the module's docking port and, after release the Shuttle, securely berth the module itself for a 'hard dock' with the orbital complex as originally envisaged but, without the need for the rather elaborate 'musical chairs' re-arrangement of Mir's existing modules to enable an unmanned docking of the new module at the forward axial or 'bow' port on Mir's hub.

Major new flight hardware to support the mission could be restricted to the mounting of a Shuttle RMS-grapple fixture at the Russian module's centre-of-mass; and new support cradling equipment in the Shuttle payload bay - possibly adapted from previously-used flight hardware.

Currently, American legislators are reported to be rather concerned that Russian orbital hardware and launch systems may predominate initially in the latest designs for an international 'Global' Space Station [1].

Such a mission as suggested here, emphasising the ability of a US launch vehicle to launch grounded Russian spacecraft, might possibly persuade such folk to look more kindly on Energiya-launched deliveries of American station-hardware.

Logistically speaking and provided the plan received prompt approval, it is suggested that the Russian module be shipped in a sealed, environmentally-controlled container from the M.V. Khrunichev assembly plant in Moscow to Sheremetyevo International Airport and flown from there by either an Antonov-225 or Lockheed C-5 directly to Orlando airport in Florida and thence to the KSC. This exercise in itself would, it is suggested, provide valuable opportunities for American and Russian aerospace engineers and logistics personnel to familiarise themselves with each other's practice - not only in readiness for the planned 1995 joint orbital flight, but also in preparation for the far-more elaborate and long-term joint operations, which will be required to support the launch, orbital delivery and in-flight operations essential for building the International Space Station, following a break of almost two decades in continuous specialised professional cooperation in this field between the two spacefaring nations.

F.A. BESWICK
Birmingham, UK

Reference

1. *Flight International*, 1-7 December, 1993, pp.45-46.

The following information has been provided by Dr Roelof Schuiling:

Mr Beswick has raised the interesting question of launching Russian spacecraft aboard the US Space Shuttle. In theory, it would not be impossible to fly major Russian hardware elements aboard the Space Shuttle and serious planning for the launch of the Russian Soyuz spacecraft to the US Space Station aboard the Shuttle was in progress prior to the decision to fly the Space Station at a high inclination orbit. Of course, centre-of-gravity factors would have to be considered.

Mr Beswick has correctly identified the requirement for a support-cradle to interface with the orbiter and this is where a programmatic issue might arise. The cradle would transfer loads into the orbiter structure and probably also carry data monitoring interfaces as well. The funding, analysis, design, and testing of such a cradle would probably take several years before it could be integrated into a shuttle flight launch preparation process. This time element would preclude flights in the time period he suggests. Also, there was no backup HST-repair mission manifested in 1994 and scheduling a US-Russian hardware Shuttle mission would not be possible in that timeframe due to the need for engineering planning, mission operations development and training.

I do not know how much structural redesign of the Russian hardware would be required to change from an ELV support scheme to one of a cradle support. Obviously structural hardpoints would have to be changed in several locations to pick up the cradle attach points. The Space Shuttle, of course, is quite flexible in its ability to support a variety of payloads.

A question in these times of tight budgets might be that of "who pays for the flight?". Design of flight support equipment and missions operations, together with flight and mission control training, would involve a substantial sum.

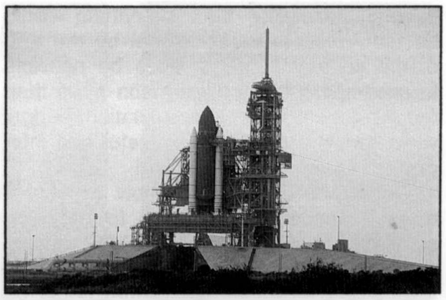
In summary: launching major Russian hardware elements aboard the Shuttle is technically feasible and probably deserves further attention. However funding and time resource limitations might preclude early operational use of the concept.

KSC Holiday Visit

Sir, I was most interested to read the article on the pre-launch preparations for STS-61 (***Spaceflight***, February 1994, p.50), 'Endeavour Switches Launch Pads'.

The enclosed photograph taken on 8 November 1993, during my holiday to Florida, shows the STS-61 Shuttle stack whilst it ws still located on launch pad 39A, one week prior to its move to pad 39B on November 15.

Incidentally, my visit to the Kennedy Space Center on 8 November coincided with the return of Shuttle Columbia atop its 747 Carrier aircraft from Edwards Air Force Base, after its 14 day STS-58 mission. From the Astronauts Memorial at Spaceport USA, the Shuttle Carrying Aircraft could be seen in the distance approaching the KSC runway just before 11 am. During the afternoon, whilst on one of the public bus tours of KSC, I was able to see (again in the distance) the Shuttle/747 Carrier combination entering the demate structure.



STS-61 (Endeavour) on Launch Pad 39A, 8 November 1993. G. ANDERSON

GEORGE ANDERSON FBIS
Berkshire, UK

Affordable Space Infrastructure

Sir, I congratulate Mark Hempsell on his fascinating article "The Space Station and Beyond" in ***Spaceflight***, January 1994. In conjunction with Mr Frieling's idea of reviving the Saturn V launcher in his December 1993 article "Return to the Moon to Stay" it presents intriguing possibilities for future space infrastructure.

The uprated Saturn V (Saturn VI perhaps?) would be the ideal launcher for a permanently manned Skylab style space station. While such a station would not be as capable as the designs currently under consideration it would be considerably cheaper, quicker to implement and expandable in stages *via* the addition of science modules in the fashion of the Russian Mir. It would also make sense to consider resupply of the station by inexpensive low-payload launchers such as the Delta Clipper or MAKS. Considering the amount of development already done on all of these elements it should not be

beyond possibility that everything could be man-rated and operational by the turn of the century. It might even be possible to accomplish this for not much more than the already agreed space station budget while giving a much more useful and integrated space infrastructure!

On a related point; just how expensive does a space station have to be, say, something between the SPELDA station concept mentioned by Mr Hempsell and the current Mir? Something that could be orbited by a single shuttle flight - a cylinder about 3 metres by 10 metres with basic life-support, communications and control with a docking port at one end and solar cell 'wings' at the other? Utilising existing technology, the cost could surely be kept significantly below that of a single shuttle orbiter? If so, the possibility of developing a 'package deal' for space presents itself. For example two Delta Clipper/MAKS orbiters, basic space station, shuttle launch of same and training for pilots, ground crew, engineers etc could be sold to countries or even large multinationals as an all-in-one space programme. Since all of the hardware would be developed for American/Russian/European programmes anyway, development expenses could be effectively written off and the package sold for manufacturing cost plus profit margin. Not only would such a plan increase space access at reduced cost but might even allow national space programmes to show an eventual net profit!

PAUL McKINLEY
Dublin

Terraforming

Sir, I take issue with the reference in the letter from D.M. Francis (*Spaceflight*, December 1993, p.429) to the Earth as 'dying', or at least 'seriously ill'. I would suggest that the Earth is made of sterner stuff than he supposes.

Geological analysis indicates, for example, that the British Isles have gone from being buried under 100 ft of ice to, at the other extreme, a situation where the Thames Valley was a semi-tropical swamp.

There is a theory that we are still in one of the milder periods of the last Ice Age, in which case the controversy about global warming may yet take on a whole new meaning.

Further analysis indicates that the dinosaurs, and related species, were wiped out by sustained meteorite bombardment. According to the 'Nemesis' theory, such bombardment was merely the most recent of a whole series of bombardments, doing immense damage to our biosphere at regular intervals and destined to continue into the indefinite future with the prospect of bringing about the end of human civilisation and perhaps of the human race itself, unless we take positive steps.

I doubt that anything we have yet done can match the destructive potential in 'Nature' itself.

As for D.M. Francis's comments about it taking four hundred years for us to gain any benefit from the terraforming of Mars, I can only presume that he is working on the assumption that we can derive no benefit from the terraforming of Mars before it is completed.

I remember being taught, in an economics course, how the differing environments within the United States helped to spur their technical development. More recently, and pertinently, the Apollo programme produced substantial benefits for America in ways unrelated to the aim of the programme itself (the non-stick frying pan being the best-known, although hardly the most important, of the examples).

In the same way, a Mars terraforming programme, from the moment it begins, may be expected to start generating benefits.

In order to be able to remake Mars to a humanly habitable environment, we are going to have to learn a great deal more about the factors contributing to a humanly habitable environment, research which can be used in a wide variety of ways on Earth itself.

In a different vein, the creation of a reliable space transportation facility, capable of moving comparatively large amounts of personnel and material from the Earth-Moon system to Mars, would greatly increase our ability to move anywhere within the Solar System. Industrial systems gathering resources from the outer Solar System for use on Mars could also gather them for use on Earth, reducing the need for mining, and other industrial processes on the Earth itself.

The psychological effect on the population of the Earth of the knowledge of an international effort, continuing over decades and more, to extend the frontiers of the human race could go a long way to bring about the political unification which other correspondents have been proposing.

With regard to the possible time-scale for the beginning of the Mars project; NASA apparently had plans in the mid-1960s which, if they had been permitted the requisite funding, would have resulted in a permanently manned Moon base and a semi-permanently manned Mars base by the mid-1980s. If this had happened we would already be accumulating information for the data-base necessary to begin work on Mars. This indicates that we could expect to begin preliminary work within 20 years of the start date. With a little hard work on the political front, the commencement of the Mars project might be announced as part of the celebrations for the year 2000 - something sufficiently dramatic, hopeful and awe-inspiring to set the new millennium off to a flying start (almost literally).

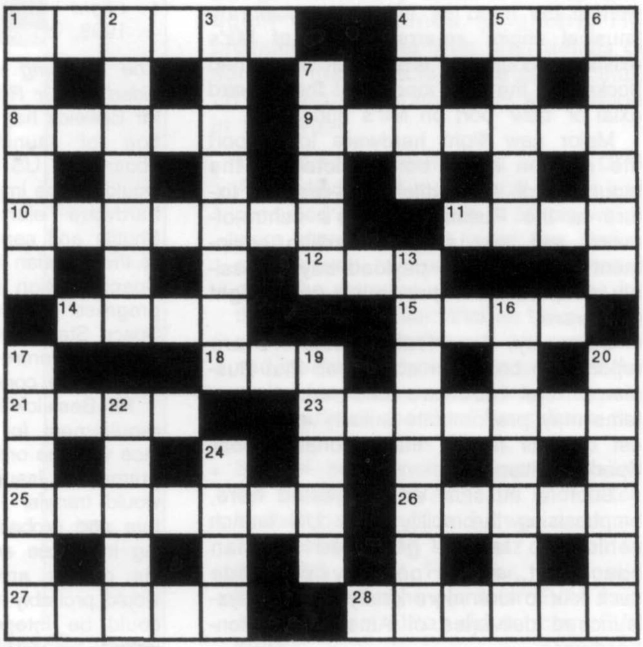
P.W. DAVEY
Dorset, UK

Spaceflight Crossword

No. 7

ACROSS
1+4. Space propulsion device (6,5)
4. See 1. Across
8. Rendezvous
9. ESA Polar Platform
10. Elongated areas of low atmospheric pressure
11. Space launcher system carried by Russian aircraft
12. Dump
14. Uselessly
15. Crater edges
18. Gaseous mixture of chiefly nitrogen and oxygen
21. Mislaid
23. ——— velocity
25. Ruled surface giving a diffraction spectrum
26. Observing
27. Subject set for discussion
28. Upward flight

DOWN
1. Bolts fastened by hammering
2. Agreement
3. Soviet space launcher
4. Relocate
5. Unit of magnetic flux density
6. Having a broad end with central depression
7. Minimum
13. Supply spacecraft
16. Honey-stone
17. See 22. Down
19. Chain of mountains
20. Emitting light strongly
22+17. Travel for an astronaut (5,6)
24. Location, for example of a launch



Solution will appear in the April issue.

Solution to Crossword No.6.

ACROSS: 7. Eureca; 8. Gemini; 10. Arecibo; 11. Again; 12. UARS; 13. Emits; 17. Plans; 18. SETI; 22. Optus; 23. Uranian; 24. Tether; 25. Scrape.

DOWN: 1. Pegasus; 2. Arrears; 3. Acrid; 4. Departs; 5. Titan; 6. Tinny; 9. Cosmonaut; 14 Cluster; 15. Temisat; 16. Pioneer; 19. South; 20. State; 21. March.

Solo Spacewalks

Sir, The article by Theo Pirard entitled 'The Cosmonauts Missed the Moon!' which appeared in ***Spaceflight***, December 1993, was very thorough and quite fascinating. In the 'Risky "Hoolahoop" Walk on the Moon' section on page 412, Pirard states, 'Until now, no astronaut nor cosmonaut had done an EVA solo'. This was included in passing to demonstrate that the solo spacewalk a lunar cosmonaut would have had to perform in lunar orbit to reach the lunar landing craft or to leave the ascent section of the lunar landing craft, after liftoff from the Moon and subsequent docking with the Earth-return vehicle left in lunar orbit, would indeed have been very risky. However the statement is decidedly incorrect.

The first few EVAs were performed solo. Alexei Leonov left his commander behind in the pressurised compartment of Voskhod 2 when he entered an inflatable airlock and then exited the vehicle. Belyayev did not even have a pressure suit. He could not have rescued Leonov if trouble had prevented Leonov's return to the spacecraft.

All the Gemini EVAs - Edward White on Gemini 4, Eugene Cernan on Gemini 9A, Michael Collins on Gemini 10, Richard Gordon on Gemini 11, and Buzz Aldrin on Gemini 12 - were performed by the mission's pilot. The command pilot remained in his cockpit seat, wearing a pressure suit connected directly to the spacecraft environmental control system. The command pilot was not equipped to exit the vehicle and assist his pilot in any way, nor could he 'reel in' a stranded spacewalker and bring him back into the cabin.

During the 1985 PBS documentary series *Spaceflight*, Michael Collins explained this saying, 'If someone outside during a spacewalk became incapacitated, even partially incapacitated, you really had no choice but to unplug him and close the hatch and come on home by yourself because there was no way that you could get an object as large as an inflated pressure suit with an immobilised person inside stuffed back inside the small right-hand seat of the Gemini. It was hard enough when the guy inside the suit was operating at 100% capacity. He still had a tough time getting himself forced back down into that seat with enough overhead clearance to close the hatch. No one could do that for him'.

The first time cosmonauts worked in groups outside the spacecraft was on the group flight, Soyuz 4 and 5, in January 1969. The first time astronauts did EVA work in pairs was on Apollo 9 during inflight evaluations of the Apollo EVA and lunar surface suits and their corresponding life support systems (David Scott and Rusty Schweickart) in February/March 1969.

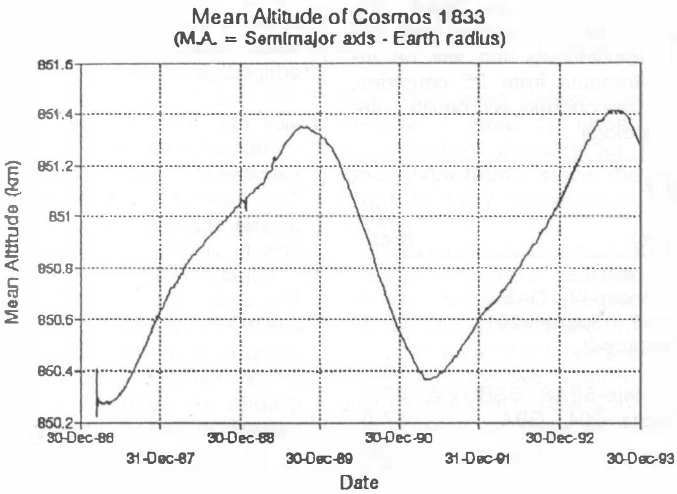
DAVID G. FISHER
Williamsport, PA, USA

Cosmos Orbits Unexplained

Sir, I would like to call the attention of your readers to the very interesting orbital behaviour of some of the Russian electronic intelligence satellites of the Cosmos 1603 family. These satellites, which are in circular orbits at 850 km altitude and 71 degrees inclination, are apparently subject to some force which offsets the influence of atmospheric drag for prolonged periods of time. The outstanding example of this behaviour is afforded by Cosmos 1833, which has undergone two two-year periods of steady increase in altitude as the **figure** shows. Most satellites at these altitudes exhibit a steady decrease in altitude of a few metres a day. (The actual value depends on several factors, notably the level of solar activity and the satellite's mass/area ratio.)

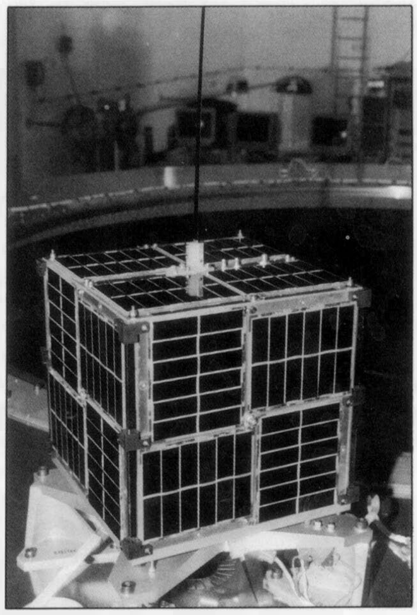
Some work on Cosmos 1603 has been done by researchers at Aston University, Birmingham showing that 14th order gravitational resonance exerts a significant effect on certain of its orbital parameters. However, there does not seem to be as yet a complete explanation of the mechanisms responsible for the altitude increases noted above. Besides the physical questions, there is also that of purpose. One must believe that the satellites were deliberately placed into these unique orbits for some reason connected with their mission, but just what that is is far from obvious.

ALLEN THOMPSON
Virginia, USA



ITAMSAT Details

Sir, Regarding the launch of five microsatellites on Ariane V59 (***Spaceflight***, November 1993, 375). I was a member of the project team responsible for CAD of circuits boards (all digital parts) and for the transmitters module of one of these, ITAMSAT.



ITAMSAT

ITAMSAT is a very small satellite entirely devoted to digital communications between radio amateurs around the world. Its shape is a cube with side dimensions of only 23 centimetres and a mass of 10 kg.

Mechanically it is a stacking of five modules with the same perimeter dimensions but slightly different height, each containing a specific part such as: receivers (five) - AFSK downlink modulator - battery charge regulator - central processing unit - transmitters (two). On the body top is located a single whip antenna for uplink while below are located four small antennas for downlink.

Stabilisation is passive, using four magnetic bars located on the vertical side of the body (+Z axis) which maintain the satellites aligned with the Earth's magnetic field. A slow spin rate is generated by reaction of solar wind photons on the surface of the downlink antennas, which are painted black on one side and white on another: the actual period of rotation today is 40 seconds.

Electrical power is provided by GaAs solar panels and 8 rechargeable NiCd batteries (from the University of Surrey) donated by AMSAT-UK to AMSAT-I for this project.

PAOLO PITACCO
AMSAT-I President
Trieste, Italy

Shuttle Payload Commanders Named

Tamara E. Jernigan, 37, **is Payload Commander on the STS-67 Astro-2 mission scheduled for December 1994 aboard Columbia. She was a mission specialist on STS-40 Spacelab Life Sciences-1 in June 1991 and on STS-52, a mission to deploy the Laser Geodynamic Satellite to measure the movement of the Earth crust, to operate the US Microgravity Payload-01, and to test the Space Vision System developed by the Canadian Space Agency in October 1992. The Astro-2 mission will study the far ultraviolet spectra of faint astronomical objects using imaging and spectroscopy and also the polarisation of ultraviolet light coming from hot stars and galaxies.**

Thomas David Jones, 38, is Payload Commander on the STS-68 Space Radar Laboratory-2 (SLR-2) mission also scheduled for December 1994 aboard Atlantis. He is to be a mission specialist on the STS-59 SRL-1 mission in April 1994. SRL-2 will take radar images of the Earth's surface for Earth system sciences studies, including geology, geography, hydrology, oceanography, agronomy and botany.

James S. Voss, **44, is Payload Commander on the STS-69 Spacehab-04 and the Shuttle Pallet Satellite-III scheduled for early 1995 aboard Discovery. He was a Mission Specialist on STS-44 in November 1991, a mission to deploy a Defense Support Program satellite and to conduct Military Man in Space and radiation monitoring experiemnts and numerous medical tests to support longer duration Shuttle flights. He was also a mission specialist on STS-53 in December 1992, a mission to deploy a classified Department of Defense payload DOD-1. Spacehab is a complement of commercial experiments flown in a pressurised module of the Shuttle's cargo bay as a supplement to the middeck area of the orbiter and SPAS-III is a group of instruments which will measure the atmosphere around the orbiter and the background clutter of the Earth's atmosphere, calling for a complicated flight plan.**

Ellen Ochoa, 35, is Payload Commander on the STS-66 Atmospheric Laboratory for Applications and Science-3 mission scheduled for September 1994 aboard Endeavour. She was a Mission Specialist on STS-56 in April 1993. Atlas-3 continues the series of Spacelab flights to study the energy of the Sun during an 11-year solar cycle and to learn how changes in the Sun's irradiance affect the Earth's climate and environment.

ESA Astronaut STS-66 Assignment

ESA astronaut Jean-François Clervoy, a Frenchman, has been selected by NASA to fly as mission specialist on board Space Shuttle Atlantis for flight STS-66 this autumn. The mission, named ATLAS 3 (Atmospheric Laboratory for Applications and Science), continues a series of flights to study the Sun's energy and its effects on the Earth's climate and environment.

The STS-66 mission is scheduled to last 10 days. In addition to the ATLAS 3 payload - with a significant ESA contribution and a strong input from European scientists - the mission will include the deployment and retrieval of the Cryogenic Infrared Spectrometer Telescope for Atmosphere, or CRISTA. Mounted on the Shuttle Pallet Satellite (SPAS), this payload is designed to explore and measure the variability of the atmosphere. CRISTA/SPAS is a joint US/German experiment. Jean-François Clervoy's main task will be to operate the Shuttle's robot arm to deploy and retrieve this experiment.

Air Force Lt. Col. Donald R. McMonagle will be Commander and the remaining crew members include USAF Major Curtis L. Brown, Jr, Pilot; Mission Specialists Scott E. Parazynski, MD and Joseph R. Tanner and Ellen Ochoa, Payload Commander, as well as mission specialist Jean-François Clervoy.

Videoconference for Mir Astronauts

Satellite videoconferencing systems set up by. Matra Marconi Space at Star City and Mission Control, Moscow, will give astronauts from the European Space Agency (ESA) on the Mir Space Station the opportunity to talk to family and colleagues.

The four ESA astronauts who are presently training at Star City for the EUROMIR project, which will involve two missions to Mir between 1994 and 1996 for two of them, will use the link to communicate with the next flight team undergoing basic training at ESA's European Astronauts' Centre in Cologne.

The system will be used by the astronauts when they are onboard the space station. The first EUROMIR flight is scheduled for September 1994 and will take one ESA astronaut to Mir for 30 days. The second trip, about one year later, will last for 135 days.

The hardware supplied and installed by Matra Marconi Space at each terminal consists of an 8W Ku band VSAT (Very Small Aperture Terminal) transceiver coupled to a 2.4m diameter antenna aligned on Eutelsat II F4 at seven degrees east.

STS-67 Crew

Veteran astronaut Stephen S. Oswald will command the STS-67 flight, an astomomy mission aboard Columbia in late 1994. The Astro-2 mission is the second dedicated to the conduct of astronomical observations in the ultraviolet spectral regions. The first Astro mission was flown in December 1990 aboard Columbia. Also on the mission are Air Force Major William G. Gregory, who will serve as the Pilot; Navy Lt Cmdr Wendy B. Lawrence, mission specialist; and payload specialists Ronald A. Parise and Samuel T. Durrance. They will join Payload Commander Tamara E. Jernigan and mission specialist John M. Grunsfeld, both of whom have already been named.

Astronauts' 1994 Congress

Astronaut Vladimir Kovalenok, who cochairs the international association of astronauts has announced that their 10th congress will be held at Lake Baikal. The 1994 congress will be marking Yuri Gagarin's 60th anniversary and will be attended by astronauts from 25 countries. The focus of the congress will be on outer space and ecology.

Forthcoming Shuttle Launches 1994

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl.
STS-62	3 March	Columbia	14 Days	USMP-2, OAST-2	39.0
STS-59	April	Endeavour	9 Days	SRL-1, Concap-IV, GAS	57.0
STS-63	June	Discovery	8 Days	Spacehab-3, Spartan-201, CGP/Oderacs-2	51.6
STS-65	July	Columbia	13 Days	IML-2	28.5
STS-66	September	Endeavour	10 Days	Atlas-3, Crista-SPAS, SSBUV/A	57.0
STS-64	September	Discovery	9 Days	LITE, Spartan-204, GBA	57.0
STS-68	December	ATlantis	9 Days	SRL-2	57.0
STS-67	December	Columbia	14 Days	ASTRO-2	28.5

Astronaut Takes Leave

Astronaut James P. Bagian, MD, PE is taking a leave of absence from NASA to work as Vice-President of Corporate Development and Medical Affairs at Somanetics Corporation, Troy, MI, where he will use his medical and engineering expertise to head up the company's clinical research activities.

He will return to flight status upon his return to NASA.

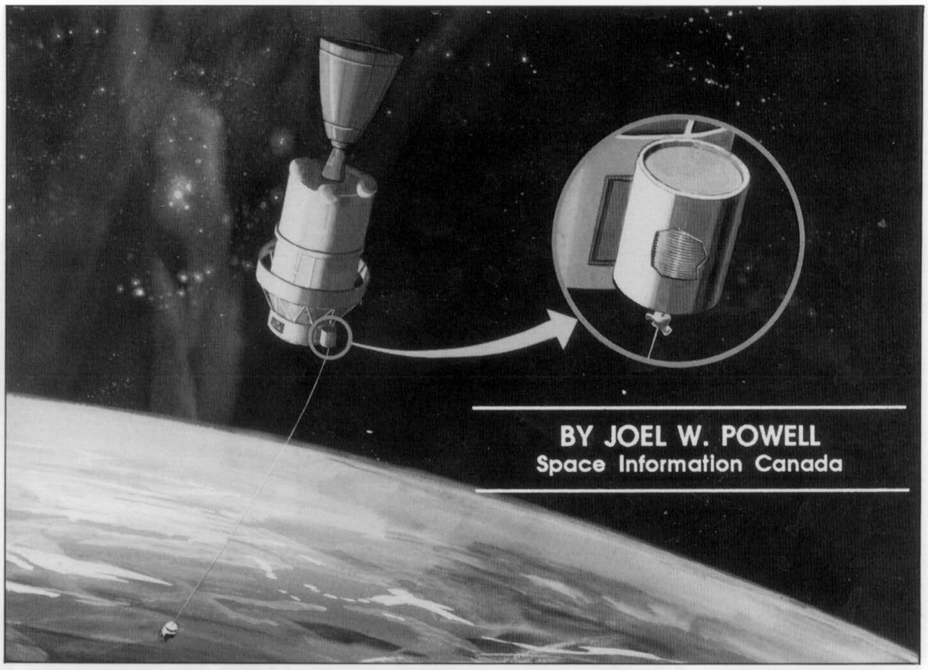
Bagian became an astronaut in July 1980 and took part in the planning and provision of emergency medical and rescue support for the first six Space Shuttle flights. He was a mission specialist on Space Shuttle missions STS-29 in March 1989 and on STS-40 in June 1991.

On his first Shuttle flight, Bagian was the principal investigator for an experiment to study the changes of cerebral blood flow and its relationship to space adaptation syndrome and space motion sickness. He was the first to treat space sickness with the drug Phenergan by intramuscular injection, which was the first successful treatment for the symptoms. This method has been adopted by NASA as the standard of care for the control of space sickness in Shuttle crews.

Bagian's second Shuttle flight was the first Spacelab Life Sciences mission, on which experiments were performed to explore how the heart, blood vessels, lungs, kidneys, and hormone-secreting glands respond to microgravity, the causes of space sickness, and changes in muscles, bones and cells which occur in humans during space flight.

Satellite Tethers Unwind

As Secondary Payloads in 1993



Artist's concept of the SEDS space tether being deployed in Earth orbit.
MARSHALL SPACE FLIGHT CENTER

Not all space experiments require a multi-tonne satellite and an operating budget of hundreds of millions of dollars. Several recent NASA experiments were pickabacked on the second stages of Delta II launch vehicles to take advantage of excess payload capacity. The SEDS space tether and the Plasma Motor Generator experiments were unlikely to have made it into space were they not flown as low-cost secondary payloads.

SEDS: Small Expendable Deployer System

Sometimes simplicity is the best way to tackle a technical problem. When NASA first attempted to deploy a tether in space on the STS-46 shuttle mission in July 1992, the experiment came to grief when a bolt (added late in the testing phase to help strengthen the deployment mechanism) snagged on the tether reel and ruined the elaborate multi-million dollar experiment. The tether stuck at a distance of only 257 m, far short of the planned 20 km deployment.

A much simpler space tether experiment flew in March 1993 as a Delta II secondary payload. The $10 million Small Expendable Deployer System (SEDS, formerly known as the Tether Dynamics Explorer) was the first of three tether experiments in the Flight Demonstration Program of NASA's Office of Space System Development.

SEDS originated in 1983 with a proposal for a space tether by Joseph Carroll, an engineer and inventor at a small firm in California called Energy Science Laboratories. Carroll later bought the space tether system from ESL and formed his own company, Tether Applications, Inc., to prepare SEDS for flight. The tether system was initially designed for the Space Shuttle (see PMG, below) but was switched to an expendable launcher following the Challenger accident.

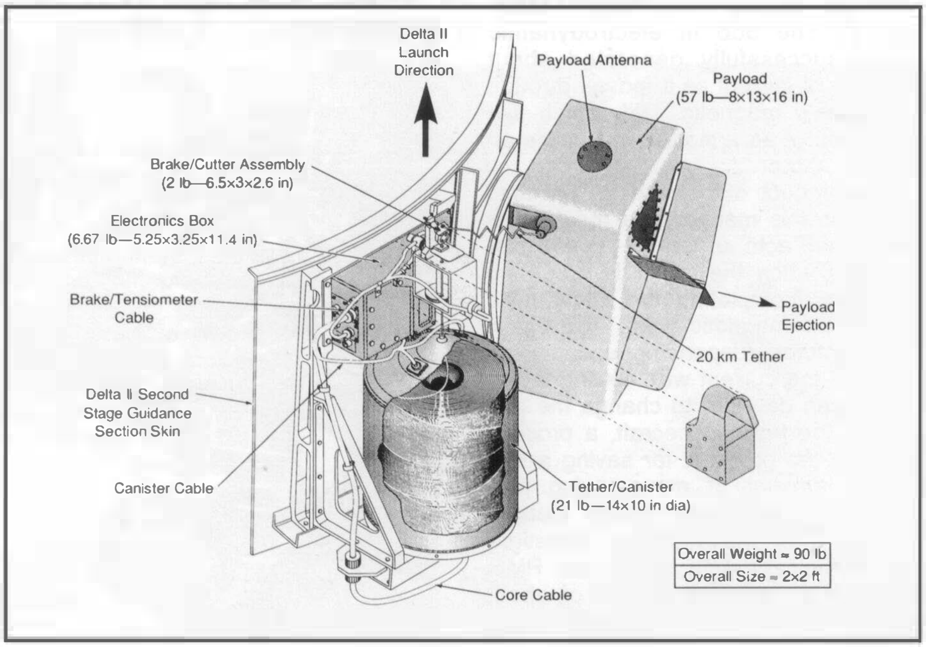
Weighing a total of only 38.6 kg, SEDS was designed to unreel a 20 km tether attached to an instrumented 25.9 kg end-mass to record tether motions (accelerations) and dynamic forces encountered during deployment. The 175 pound-test (785 N) "Spectra" polyethylene fibre tether was wound into a canister the size of an American one-gallon jerry can. The tether would be severed once it reached the full 20 km length, and the diagnostic payload and tether would descend into the Earth's atmosphere and burn up.

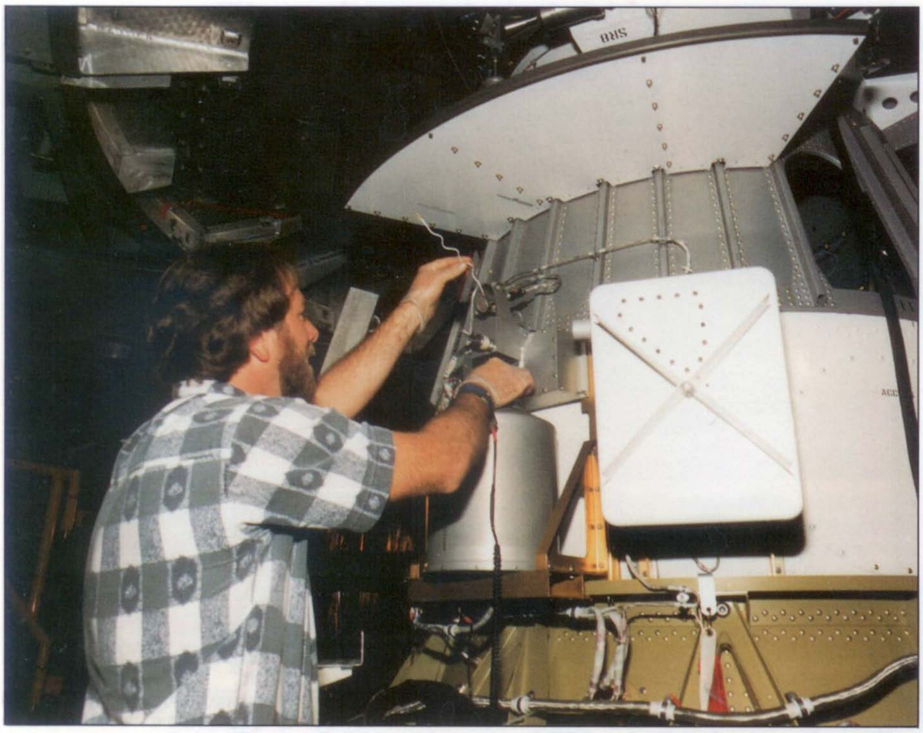
The moment of truth for SEDS arrived on March 29, 1993 as Delta 219 lifted off smoothly from Cape Canaveral at 10:09 pm EST. After separation of the 19th Navstar satellite and its PAM upper stage, the SEDS diagnostic payload was ejected by springs some 63 minutes after liftoff. Tether deployment occurred at an altitude of 720 km in a direction downwards toward the Earth. After unreeling smoothly for 75 minutes, the tether was gradually braked to a stop after passing the 19 km mark.

When the tether stopped at the full 20 km extension, a 14 minute period followed where the damping motions of the tether were recorded. The tether was then severed and the experiment was successfully concluded. NASA Project Manager Jim Harrison of the Marshall Space Flight Center was very happy with the results. "Based upon the quick-look data we have so far, it appears we had a very smooth operation", said Harrison. "We wanted to verify that a system like SEDS will deploy a tethered object successfully and what we've seen tonight indicates that it will". A SEDS II follow-on has been manifested for flight on a Delta II in March 1994.

SEDS apparently will not be the only space tether experiment (other than the re-flight of TSS from STS-46 in 1996) to fly in the foreseeable future. The German space agency DARA plans to test one on a Russian Photon spacecraft in 1995. The 50 km tether experiment is designated RAPUNZEL - Rope Attached Piggyback Unit Zooming on Environmental data!

The Small Expendable Deployer System (SEDS) payload. NASA




Final adjustments are made on the SEDS tether hardware (left) and the deployable payload (right) mounted on the Delta second stage. NASA

PMG: Plasma Motor Generator

The Plasma Motor Generator was the second tether applications test flight, launched by Delta 221 on June 26, 1993 with yet another Navstar satellite. Developed by the Johnson Space Center in Houston, the PMG experiment was intended to assess the ability of a space tether to generate an electrical current and to investigate the use of hollow cathode assemblies to dissipate accumulated electrical charges on an orbiting spacecraft.

The mission, a rarity for JSC in that it utilised an expendable rocket, yielded excellent results. "We achieved everything we hoped we would", said Principal Investigator Dr James McCoy of JSC, "Our results went well beyond our primary requirements". The 500 m electrodynamic tether successfully generated about 0.3 amp of current as it moved through the Earth's magnetic field, much like the action of an armature coil inside an electric motor.

A byproduct of generating electrical energy in this manner is a mechanical force that acts upon the spacecraft structure when the tether is grounded to space (completing the circuit with the Earth's magnetic field). This thrust or drag force (depending upon which direction the current was flowing in the tether) can be used to change the altitude of the host spacecraft, a process that has the potential for saving a significant amount of manoeuvring propellant on an orbital space station. According to the Principal Investigator, preliminary data show that PMG achieved an altitude change of about 9.1 m in one mode and about 91.4 m in the opposite direction.

PMG also successfully demonstrated the dissipation of built-up electrical charge in space. The hollow cathode assemblies released xenon gas to create a ball of plasma (ionised gas) that served to "ground" the tether to the tenuous upper atmosphere (apogee altitude of the Delta stage was 865 km). The hollow cathode worked well, successfully discharging the electrical current generated by the tether. One day electromagnetic tethers may be used to dissipate accumulated electrical charges that sometimes plague geosynchronous communications satellites during periods of high solar activity.

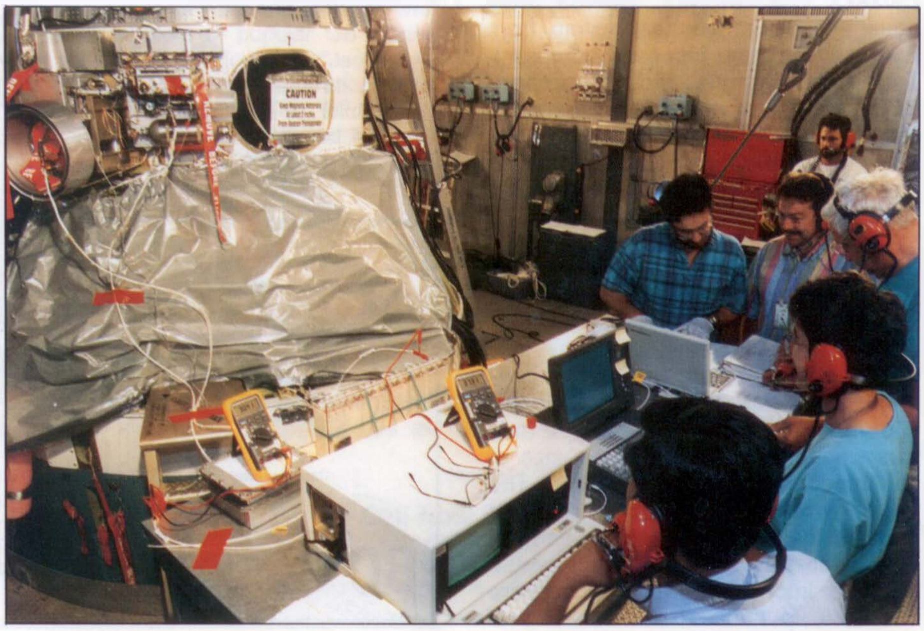
PMG consisted of four hardware elements on the Delta II upper stage. The Near End Package served as the controlling element of the experiment, while the 27 kg Far End Package was deployed at the end of the tether and contained the experiment sequencer. The Plasma Diagnostics Package contained an ion mass spectrometer to make local environmental measurements, while the electrical power supply and telemetry interfaces with the Delta stage were housed in a SEDS electronics box supplied by the Marshall Space Flight Center.

The tether deployment mechanism was originally designed for a Hitchhiker payload on the Space Shuttle before being transferred to the Delta. The 11.4 kg mechanism, developed by JSC and Joseph Carroll's Tether Applications Inc (see SEDS), deployed the 500 m tether in about four minutes at a rate of two metres per second. The experiment was restricted to four hours duration by the life of the Delta batteries. Ten ground-based radars, magnetometer stations and optical sensors were also employed to support PMG.

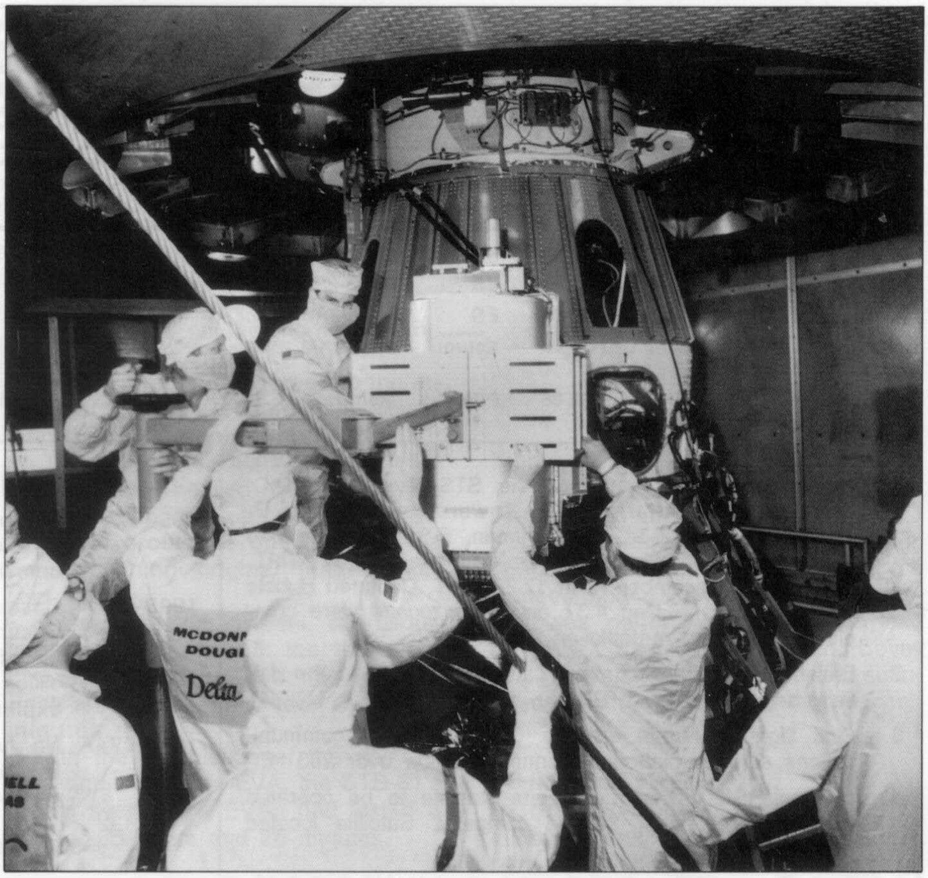
Future Delta Secondary Payloads

The SEDS and PMG payloads launched in 1993 and the DUVE payload launched in 1992 (see opposite) are the first of several add-on payloads that will fly on Delta II upper stages during the next several years. After SEDS II, an international student organisation plans to deploy a small satellite into orbit using the tether system. Students for the Exploration and Development of Space (also known as SEDS) hope to launch their tiny 36 cm SEDSAT in 1995 via a tether from a Delta II upper stage. The

Pre-launch checkout of the Plasma Motor Generator payload which is at the top left corner of the photo. The storage bottle (right side of payload) contained xenon gas used in the dissipation of electrical charges. Adjacent and left is the tether deployment reel. NASA



DUVE: The Small Payload Telescope



Technicians position the DUVE telescope with an articulated handling fixture as they prepare to attach it to the second stage of Delta 212. NASA

On July 24, 1992, Delta 212 was launched carrying the joint NASA - Japanese Geotail scientific satellite. The Diffuse Ultraviolet Experiment (DUVE) telescope and electronics box were mounted as a secondary payload on opposite sides of the second stage of the Delta. The entire payload including the electronics box had a mass of only 106 kg. DUVE was a small telescope, refurbished after an earlier sounding rocket flight, for studying the interstellar medium at ultraviolet wavelengths not accessible to Earth-bound observatories. The telescope employed an unusual set of spherically curved "grazing incidence" mirrors to reflect and focus the extreme ultraviolet radiation.

The DUVE telescope was originally launched on a sounding rocket to attempt the first observations in the far ultraviolet portion of the spectrum (950 to 1,100 Å). In April 1990 the instrument was lifted into space for a brief five minute suborbital flight on a Black Brant rocket (vehicle 36.063 UG) from the White Sands Missile Range. The flight was, however, too short for any meaningful data to be collected and this prompted the research group headed by Professor Stuart Bowyer of the University of California at Berkeley to seek an orbital flight opportunity.

The goal of DUVE was to measure clouds of hot ionised gas in the constellation of Grus to reveal details of the internal structure of our galaxy. According to Prof Bowyer (who was also in charge of the Extreme Ultraviolet Explorer satellite that was launched one month prior to DUVE) the galactic interior can be likened to a Swiss cheese where the holes are hot bubbles of hydrogen gas swept out of the interstellar medium by supernovae explosions. "The question we are trying to answer", says Bowyer, "is whether the galaxy is mostly cheese or mostly holes".

Prof Bowyer is a pioneer in the observation of far ultraviolet emissions from space. The near ultraviolet wavelengths (those greater than 980 Å) were observed from space in the 1960s from sounding rockets and the OAO satellites, but conventional wisdom held that the far ultraviolet wavelengths would be absorbed by interstellar gas and dust. Prof Bowyer chose to disagree and convinced NASA to fly a space experiment to investigate his theory. The Extreme Ultraviolet Survey experiment (MA-083) was flown on the Apollo-Soyuz mission in July 1975 and proved that far ultraviolet radiation could be observed from space with the discovery of four separate sources of emission.

The DUVE mission began about 33 minutes after liftoff when the protective cover for the telescope was opened following separation of the Geotail satellite. DUVE was provided with special shielding to protect it from the exhaust plume of Geotail's PAM-D upper stage motor. Data gathering commenced about 11 minutes later when the Delta stage entered the Earth's shadow, and continued throughout the night passes of the following five orbits. The Delta stage provided active stabilisation. during the first orbit, reverting to spin-stabilisation after the propellant depletion burn at the beginning of orbit 2. The spectrometer worked flawlessly through six orbital nights (one more than planned) until the battery was depleted.

The DUVE mission was not without an element of drama. Tracking stations at Hawaii and in the Indian Ocean failed to receive real-time telemetry from the experiment during the first pass. To the relief of the experiment group, contact was finally established at the end of the first orbit. Fortunately the data were recorded aboard the DUVE payload and the tape was downloaded to the ground. The telemetry record was delivered to Berkeley for analysis about one month after launch. According to project manager Jerry Edelstein, about 214 minutes of data were recorded during the mission, a more than 40-fold improvement on the first brief sounding rocket flight. ■

momentum accumulated during the extension of the tether will be converted to kinetic energy when the tether is severed, propelling the microsat into a different orbit, analogous to the action of a slingshot.

A group of Danish university students are preparing to deploy a small satellite (though not by a tether) from a Delta II in 1995. The ORSTEDSAT is designed to perform a precision survey of the Earth's magnetic field. The SCOT (Student Coherent Orbiting Transponder) experiment is scheduled for a Delta II launch sometime in 1994 to calibrate ground tracking stations for American universities.

Perhaps the most intriguing add-on experiment will be the University of Maryland's "Ranger" project, slated to fly in 1997 on the Delta upper stage of the Lageos-3 satellite, provided that funding can be secured for Lageos. Ranger is a 500 kg payload designed to test teleoperated robot manipulator arms (waldoes) for application to space station maintenance and repair. The Ranger project originated with studies of robotic manipulator payloads at Maryland in an underwater training facility like that used for astronaut EVA training.

Delta secondary payloads fit in very well with the new NASA philosophy of "smaller and cheaper" and promise to provide the space agency with the opportunity to test a number of innovative concepts that may not otherwise make it into space.

Acknowledgement

Special thanks to Jerry Edelstein at Berkeley and the NASA Public Affairs staffs at MSFC, JSC and KSC for providing the photographs and background material for this article.

References

Joel W. Powell, "Delta Add-On Payloads", ***JBIS*, 37**, (5), May 1984.

Space News, February 1-7, 1993. (Ranger).

Omni, September 1988. (SEDS/Carroll).

SATELLITE DIGEST-262

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Endeavour	1993-075A	Dec 2.39	KSC	Shuttle	94,976	Dec 4.35	28.47	96.46	586	592	[1]
NATO 4B	1993-076A	Dec 8.08	ER	Delta-2	1,434	Dec 17.86	4.16	1,440.79	35,107	36,549	[2]
Telstar 401	1993-077A	Dec 16.03	ER	Atlas-2AS	3,375	Dec 18.86	3.82	1,030.24	19,100	35,724	[3]
DBS 1	1993-078A	Dec 18.06	Kourou	Ariane 44L	2,860	Dec 26.60	0.07	1,436.30	35,772	35,809	[4]
THAICOM 1	1993-078B				1,080	Dec 22.59	0.43	1,378.17	33,928	35,362	[5]
Molniya-1 87	1993-079A	Dec 22.86	Plesetsk	Molniya	1,600 ?	Dec 22.91	62.82	702.98	440	39,182	[6]

NOTES

1. Carried seven astronauts on the STS-61 mission: R.O. Covey (commander), K.D. Bowersox (pilot), K.C. Thornton, C. Nicollier, J.A. Hoffman, F.S. Musgrave and T. Akers (mission specialists). Launched 09.27 GMT, landed KSC December 13 at 17.26 GMT. Captured Hubble Space Telescope Dec 4.37 and after repairs were completed HST was re-deployed Dec 10.44.
2. British-built military communications satellite, to be initially deployed over 6 °E.
3. First flight of Martin Marietta GE-7000 series communications satellite platform. Planned location over 263 °E.
4. Hughes HS-601 communications satellite to be operated by Direct Broadcast Service company. Satellite located over 258 °E.
5. First Thai satellite (based upon Hughes HS-376 bus), launched for Shinawatra Satellite Public Co Ltd. To be located over 78.5 °E.
6. Communications satellite, co-planar with and presumably replacing Molniya-1 77.

ADDITIONS AND UPDATES

1983-058A EUTELSAT-1 F1 was relocated over 48 °E during December 1993.

1984-081A EUTELSAT-1 F2 has been retired from operations and has been boosted out of the geosynchronous orbit band.

1990-037B Hubble Space Telescope was repaired during the Endeavour/STS-61 mission (see above), and the opportunity was taken to re-boost the satellite from a 586-596 km orbit to 592-601 km. During the repairs the mass of Hubble was increased by 117 kg to 11,230 kg.

1990-037C This object is a solar panel from Hubble Space Telescope, discarded 1993 Dec 6.20 during the astronaut repair mission.

1991-027B A further series of re-boost manoeuvres of the Compton Gamma Ray Observatory has taken place: by 1993 December 20 the orbit had been raised to 441-452 km.

1992-087A Cosmos 2223 was de-orbited on 1993 December 16 after 372 days in orbit - a record for a Russian unmanned photoreconnaissance satellite.

1993-057A Cosmos 2262 was destroyed in orbit on 1993 December 18 after operating for 102 days - a record for this class of satellite: all previous satellites of this class have ended their lives with an explosion.

1993-074A No further orbital data have been issued for DSCS-3B 4 following publication of the transfer orbit data.

Summary of Known Launches in 1993

Country/Organisation	Launches to Orbit	Launch Failures	Satellites Launched
Arianespace	7	-	-
Brazil	-	-	1
China	1	-	1
European Space Agency	-	-	1
Former Soviet Union (FSU)	47	1	59
France	-	-	3
India	-	1	1
Italy	-	-	2
Japan	1	-	1
Korea (South)	-	-	1
Luxembourg	-	-	1
Mexico	-	-	1
Portugal	-	-	1
Spain	-	-	1
Thailand	-	-	1
United States	23	2	32
Totals	79	4	107

Notes: The number of satellites excludes payloads carried on launch failures. The US excludes the SEDS and PGM experiments carried on two Delta second stages. There might be additional FSU launch failures which have not yet been announced.

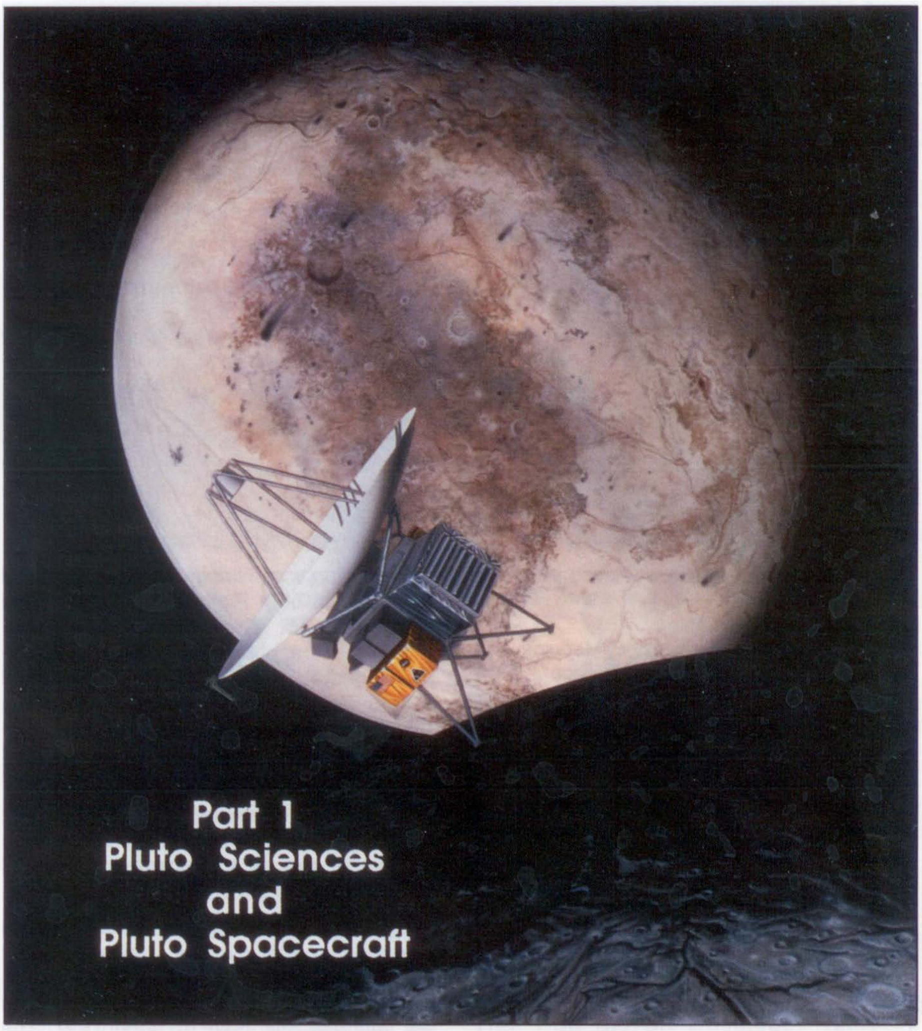
Last But Not Least -

Trip to Pluto

As a planetary system, Pluto is small in size but big in mystery. Pluto's neighbours, the gas giants, almost make it an insignificant speck in the outer Solar System. It was not even discovered until 1930, and its relatively huge moon Charon was not discovered until 1978. But this pint-sized binary planetary system has captured the popular imagination more than perhaps any other planet save Mars.

Its very remoteness has both fuelled our imagination and made it a difficult place to visit. Known as the "farthest planet" from the Sun, its highly elliptical 248-year orbit is sometimes - as it is now - inside Neptune's, making it the "farthest planet... most of the time". But in 1999, as it heads away from perihelion, Pluto will again cross outside Neptune's path, and will reign as the king of distance until 2227. And it is for this reason, its rapid departure from its relative closeness to the Sun, that gives urgency to the human probing of its secrets.

NASA's Jet Propulsion Laboratory has proposed a highly focused, low mass and low cost mission to Pluto by two spacecraft to perform the first reconnaissance of the only known planet left unexplored. Aiming for separate 1999-2000 launches, it is hoped both spacecraft will reach Pluto before its atmosphere freezes into a dusting of snow.



After a planned launch in 1999, two separate spacecraft will make the 4,500 million kilometre journey to Pluto and its moon Charon in seven to ten years.

ARTIST: PAT RAWLINGS, SAIC

Exploring the Pluto/Charon System [1]

Pluto's inclined and eccentric orbit of the Sun carries it between about 30 and 50 AU, so Pluto exhibits a wide seasonal range. Pluto is known to have a thin atmosphere and quite a large moon, Charon*, which orbits at a distance of about 20,000 km. Charon rotates around Pluto with a period of 6.39 days - the same length as Pluto's rotational period. Interest in Pluto and Charon has increased since the 1989 encounter with Neptune's moon Triton by *Voyager 2*. Triton is a near twin of Pluto in size and albedo, and has revealed an extremely complex geology, with active surface eruptions, polar ice caps, seasonal volatile changes, and limb hazes. These revelations fuel scientific imaginations about what might be found on Pluto and Charon. Only a spacecraft encounter can provide this kind of information.

As Pluto has only recently passed perihelion, its surface is the warmest it will be for two centuries. It is essential that the system be explored before the 2020s; as the planet races from the Sun, its atmosphere will freeze and fall to the surface, where it will lay until evaporated by the next "close" encounter with the Sun.

The key questions to be answered about Pluto and Charon concern the origin of this "dual-planet" system and its relationship with the rest of the Solar System. Recent Hubble Space Telescope images were the first to distinctly resolve Pluto from Charon, revealing that they orbit a barycentre about 900 km above Pluto's surface. As suspected, Pluto's estimated density (~2.1 g/cm^3) is higher than Charon's (~1.3 g/cm^3). Because of a greater uncertainty of Charon's diameter, its density estimate is less certain, but clearly it is different enough to indicate distinct compositional differences between the two. By its density, we can infer that Pluto has a substantial rocky component. A very tenuous atmosphere containing methane has been detected around Pluto using stellar occultation. There is also spectral confirmation of nitrogen, carbon dioxide, and methane ices on Pluto, and water ice on Charon. At surface temperatures of perhaps 40 K, methane ice relaxes over geologic time scales for larger topographic features, while water ice behaves more like terrestrial rock. Thus, there is "the speculative but interesting possibility that Pluto's surface may harbour only the record of more recent impacts, while Charon's harbours a long-term integrated flux. One awaits a spacecraft mission to learn if this is indeed the case" [1].

Ground-based measurements have shown that Pluto's surface reflectance varies, with some longitudinal variations and asymmetrical polar caps [2]. Charon is also thought to have at least subtle surface markings. With at least a transient atmosphere, there is a mechanism on Pluto for material transport, such as frost sublimation. On both bodies, radiation effects may cause surface chemistry changes, resulting in colour and brightness variations beyond what would be caused by impacts alone. Certainly, there is much to learn: each first planetary encounter has brought many complete surprises.

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* "Charon" is pronounced with *Char* as in "shark" and *on* as in "on and off", with the accent on *Char*.

Primary Scientific Objectives

The science goals and measurement objectives for a first reconnaissance mission to Pluto were formulated and prioritized by NASA's Outer Planet Science Working Group, and are listed in Table 1. The three category "1a" science objectives were identified as the highest priority required for this first mission, with the "1b" and "1c" category objectives considered desirable but non-essential. Note there is no ranking implied within the categories.

Table 1: Pluto Core Measurement Objectives.

1a
Characterize Neutral Atmosphere
Characterize Global Geology and Morphology
Surface Composition Mapping
1b
Surface and Atmosphere Time Variability
Stereo Imaging
High Resolution Terminator Mapping
Selected High Resolution Surface Composition Mapping
Characterize Ionosphere and Solar Wind Interaction
Search for Neutral Species
Search for Charon's Atmosphere
Determine Bolometric Bond Albedos
Surface Temperature Mapping
1c
Characterize Energetic Particle Environment
Refine Bulk Parameters (R, M, ρ)
Search for Magnetic Field
Search for Additional Satellites and Rings

The goal of an initial reconnaissance of the Pluto-Charon system is to understand the physical and geological processes on the surface, the surface composition, and the composition and nature of any atmosphere found on Pluto and Charon. We believe that these top-priority objectives can be met within the cost, size, and mission time constraints of a very small spacecraft mission, but to do so will require new developments in instrumentation (described below). It is anticipated that the baselined spacecraft and instrument package will provide comparable or better scientific coverage of Pluto and Charon than was provided by *Voyager* at Triton.

To meet the category 1a science objectives, a series of measurement requirements were generated based on current knowledge of the Pluto-Charon system. These requirements were used to guide the design of the Pluto "strawman", or example, mission science payload. The specific measurement requirements for each of the Category 1a objectives are:

Neutral Atmosphere Characterization

Composition: Determine the mole fraction of N_2, CO, CH_4, and Ar in Pluto's atmosphere to at least the 1% level. Minor constituent composition is a 1b objective.

Thermosphere Thermal Structure: Measure T and dT/dz at 100 km resolution to 10% accuracy at densities down to 10^9 cm^{-3}.

Aerosols: Characterize the optical depth and distribution of near-surface haze layers over Pluto's limb at a vertical resolution of 5 km or better.

Lower Atmosphere Structure: Measure T and P at the base of the atmosphere to accuracies of 0.1 μbar and ±1 K.

Geology and Geomorphology

Monochromatic Mapping: Obtain 1 km/lp (line pair) monochromatic global coverage of both Pluto and Charon. The resolution requirement is to be obtained at the sub-spacecraft point in each image; it is understood that a combination of image projection effects and spacecraft data storage limitations may degrade resolution away from the sub-spacecraft point.

Colour Mapping: Obtain 3-10 km/lp global coverage of both Pluto and Charon in 3-5 colour bands. The resolution requirement is to be obtained at the sub-spacecraft point in each image; it is understood that a combination of image projection effects and spacecraft data storage limitations may degrade resolution away from the sub-spacecraft point.

Phase Angle Coverage: Obtain sufficient imaging at moderate and high phase angles to specify the phase integrals of Pluto and Charon.

Image Dynamic Range and S/N: For all imaging, provide dynamic range to cover brightness contrasts of up to 30 (i.e., normal albedo between 0.03 and 1) with an average S/N goal of about 100. The darkest portions are expected to produce a lower S/N.

Surface Composition Mapping

Mapping Coverage and Resolution: Obtain infrared spectroscopic maps of at least one hemisphere of Pluto and Charon with 5-10 km/pixel resolution. If payload accommodations permit, obtain this coverage globally. If payload accommodations do not permit global coverage at this resolution, obtain infrared spectroscopy maps with a resolution of at least 50-100 km/pixel on the non-closest approach hemispheres of each body.

Spectral Coverage and Resolution: For each spatial resolution element, obtain a spectral resolution of 300 over the entire region 1.0-2.5 μm or a resolution of 400 over the entire region 1.5-2.5 μm.

Mapping S/N and Dynamic Range: Obtain S/N >100 everywhere, with sufficient dynamic range to meet this requirement.

It is required that these specific measurement requirements be obtained despite several constraints: a flight time of 7-10 years, a nominal flyby velocity of 12-18 km/sec, use of two spacecraft, a technology freeze in 1995 for a fiscal 1996 new start, a payload mass allocation of 7 kg, a payload power allocation of 6 W, a pointing stability of 10 μrad/sec, and a cost allocation of ~$30 M (of a total life cycle project cost of $450-750 M in FY 1993 dollars). This is in addition to being at Pluto, the very low photon flux (Pluto's distance from the Sun at encounter will be over 30 AU), and the extremely tenuous atmosphere to be measured.

"Strawman" Science Payload

To see if a set of instruments could be put together to meet the stated science requirements and still keep within the mandated spacecraft and mission constraints, a "strawman" payload was defined. The strawman instruments described below are not by any means final descriptions; the instruments that will actually fly will be selected from proposals submitted in response to a future Announcement of Opportunity.

The concepts employ advanced materials and electronics, novel optical arrangements, shared optics, and highly integrated packages, some of which were developed for other projects (e.g., the Strategic Defense Initiative). Breadboards of critical items are due by the end of April, 1994. "Science requirements creep" will be avoided by issuing early, well-defined science measurement objectives and by making principal investigators responsible for accommodating the impacts of added requirements within their available resources.

Example Visible Imaging System

- **Visible Imaging System** - Telescope: Richey-Chretien optics (all reflecting); 750 mm focal length, 75 mm aperture.
- **Visible CCD Camera** - 1024 x 1024, 7.5 μm pixel Loral CCD; 10 μrad resolution; 0.6 deg field of view; 4-8 position filter wheel and/or grism; shutter.

This example Visible Imaging System meets the geology and geomorphology objectives by providing the capability for sub-kilometre imaging resolution while the spacecraft is inside of 100,000 km range. Complete colour coverage will be obtained inside of 500,000 km. With the relatively short readout times, there will be sufficient time to carry out the observations. The data compression and encoding plan will allow all the data to fit within the spacecraft's memory.

Example Infrared Mapping Spectrometer

- **Telescope** - Same optics as CCD camera. 75 mm aperture for a 42 μrad resolution at 2.5 μm.
- **Focal Plane** - Mirrored slit alongside visible CCD at focus; grating spectrometer onto infrared detector.
- **Infrared Detector** - 256 x 256, 40 μm pixel NICMOS HgCdTe array; $\lambda/\Delta\lambda$ ~300 over 1.0 to 2.5 μm; detector flight qualified by the Hubble Space Telescope; pixel field of view is 53 μrad; push-broom imaging.

The Infrared Mapping Spectrometer example shares the same foreoptics and some signal chain electronics with the example Visible Imaging System. A fixed grating would provide sufficient spectral resolution and S/N to meet the surface composition science objectives and al-

low the detection of condensed frosts of CO, CO_2, CH_4, etc. At a range of about 200,000 km, a complete map of Pluto can be measured in about 30 minutes with a spatial resolution of 10 km.

Example Ultraviolet Spectrometer

- **Telescope** - Separate UVS instrument; use one channel of the *Cassini*-developed ultraviolet spectrometer system to cover extreme ultraviolet.
- **Instrument** - Single channel covers 55-200 nm; single resolution mode $\Delta\lambda$ = 0.5 nm.

The strawman UVS is a single channel, fixed resolution mode *Cassini*-based UVS. It provides a measurement of the composition of the neutral atmosphere by detecting spectral features during the solar occultation and by studying Pluto's airglow. It requires being pointed at the Sun during at least one Pluto occultation, ingress or egress. Additional measurements can be made in direct scanning modes of the surface. This will meet all the neutral atmosphere structure and composition objectives except the measurement of the surface temperature and pressure.

Example Uplink Radio Science Experiment

- **Hardware** - Combined with telecommunications subsystem; ultrastable oscillator (at least 10^{-14} stability over ~1 minute).
- **Science Drivers** - Surface temperature and pressure profile; solar occultation and Earth occultation nearly simultaneous.

The example Uplink Radio Science Experiment is integrated into the RF telecommunications subsystem and includes several additional components such as an upconverter, mixer, phase detector, and an ultra-stable oscillator. *Mars Observer's* ultra-stable oscillator meets this stability requirement; a prototype is being built to demonstrate needed mass and power reductions. The Uplink Radio Science Experiment provides complementary data to the UVS and completes the temperature and pressure profile to the surface.

Spacecraft Subsystems

The Pluto mission spacecraft has seven subsystems: Telecommunications (radio frequency), Electrical Power and Pyrotechnics, Attitude Control, Spacecraft Data, Structure, Propulsion, and Thermal Control.

Spacecraft design has been driven by three requirements embodying cost, schedule, and performance, in that order. Cost is clearly the most important: if at any time during the course of the mission development it becomes apparent to NASA that the development cost cap is going to be exceeded, the Pluto mission team can expect the project to be cancelled.

The second spacecraft driver is the need to get to Pluto as quickly as possible. This requisite stems from the Outer Planet Science Working Group science objectives and the implication of a short development cycle and cruise both contributing to lower cost.

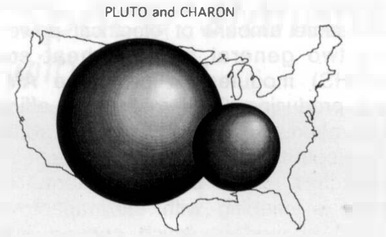
The third spacecraft driver, completing the science objectives, defines the primary function of the spacecraft. The scientific objectives of the mission define what the spacecraft has to be capable of doing. From these objectives come performance requirements, such as electrical power, data storage, communications capability, propulsive capability, thermal control, pointing control, and a long list of other resources or capabilities which the spacecraft must provide to the instruments.

From the fiscal 1992 baseline spacecraft wet mass of 165 kg, Advanced Technology Insertion (ATI) work (discussed in Part 2) has brought the mass to <120 kg (wet) for the 1993 baseline design (Table 2). The selection of technologies for incorporation into each subsystem was driven by the desire to:

- reduce mass
- reduce power consumption
- reduce flight time
- keep cost and risk within the mission context
- take advantage of existing activity in relevant technology areas.

Telecommunications

The Telecommunications subsystem consists of a 1.5 m diameter high gain antenna and the RF electronics. In the 1992 baseline design, the mass of the subsystem is 25.2 kg, and power consumption is 28 W while transmitting. Both the transmit (downlink) and receive (uplink) signals operate at X-band (~8 GHz). The downlink rate is about 80 b/s at Pluto encounter range to a 34 m Deep Space Network station. A higher rate of ~320 b/s is possible using the larger 70 m antennas of the DSN. Advanced technology incorporated into the 1993 baseline includes a lighter composite structure antenna, high density electronics packaging, and higher efficiency RF amplifiers. These advances could reduce the mass of the subsystem to 12.75 kg and the power consumption to 22 W while transmitting. In addition, a Ka-band (~32 GHz) option is in development, which could improve the data rate.



Advanced monolithic microwave integrated circuit and multi-chip module packaging technologies are the key to reducing the receiver portion of the transponder mass by 50% and increasing functionality to include the Command Detector Unit within the same module.

Power

The Electrical Power and Pyrotechnics subsystem consists of a radioisotope power source to generate power, power electronics for voltage conversion, regulation, transient peak power output, switching and fusing, and pyrotechnic device initiation (explosive bolts, pyro valves, etc.)

The 1992 baseline design has a mass of 23.2 kg and generates 63.8 W of power after nine years of operation. Power is generated by a radioisotope thermoelectric generator, which uses five general purpose heat source modules. Power consumption of 64.4 W during the encounter mode includes a 20% contingency for expected power growth as the design matures. Approximately 15 W is lost in DC-DC conversion and regulation inefficiency during the highest power modes. The current best estimate for power consumption during post-encounter downlinking (the highest power mode) is 52.31 W, plus contingency. An additional 10% margin is needed in most modes to account for uncertainties in the design process, the decay of the power source and the aging of the spacecraft as a whole.

Advanced technology which was considered for the 1993 baseline design could reduce the mass of the subsystem to ~14 kg for the same power output. Technologies such as alkali metal thermoelectric converters (AMTEC) were considered to dramatically increase the

Table 2: Spacecraft Baseline Mass Allocations.

Subsystem	1992 Baseline (kg)	Goal (kg)	1993 Design (kg)
Telecommunications	25.2	16.8	12.75
Electrical Power	23.2	12.5	19.4
Attitude Control	2.7	2.1	6.65
Spacecraft Data	7.0	4.5	6.5
Structure	20.0	14.6	14.6
Propulsion	20.1	13.1	9.9
Thermal Control	4.0	3.5	3.7
Science Payload	9.0	7.0	7.0
Total	111.2	74.1	80.5
Contingency	29.5 (26.5%)	20.1	31.3 (38.9%)
Total Dry Spacecraft	140.7	94.2	111.8
Propellant (ΔV M/S)	24.6 (350)	16.1 (350)	6.9 (130)
Total Wet Spacecraft	165.3	110.3	118.7

efficiency of the subsystem, generating the same amount of electrical power using two general purpose heat source (GPHS) modules. A prototype AMTEC cell producing 3 W with 10% efficiency has been developed. Through additional development, a 3 W, 16% efficient cell is expected to be delivered soon. Other work is ongoing with thermophotovoltaic (TPV) converters which convert infrared radiation from the hot surfaces of two GPHS modules to electricity using low bandgap photovoltaics, but a number of lifetime and risk issues need to be resolved before their incorporation into the baseline.

Both AMTEC and TPV systems require a substantial development commitment to be available for the Pluto project by the 1995 technology freeze date. Because such a commitment was not possible within today's funding profile, neither AMTEC nor TPV were selected for the 1993 baseline, in spite of substantial Pluto ATI-funded progress. A more conservative application of unicouple converters, as on *Galileo* and *Ulysses* (and planned for *Cassini*), was selected, permitting a modest mass reduction from 23.2 to 19.4 kg.

Attitude Control

The Attitude Control subsystem includes Sun and star sensing devices, an inertial reference unit, electronics for interfacing with the central computer in the Spacecraft Data subsystem, and electronics and switches to drive the thrusters in the Propulsion subsystem. The star sensing device or star camera, with its software, can determine the spacecraft's three-dimensional orientation by imaging star fields and comparing them with a catalog of stars in the computer's memory. The Sun sensors are used to help determine orientation in the event of a star camera failure. By commanding the small cold gaseous nitrogen thrusters in the Propulsion subsystem, the Attitude Control subsystem can change or maintain the spacecraft's orientation. The 1992 baseline design has a mass of 2.7 kg and consumes 11.5 W of power.

New technology for a star tracker camera weighing <500 grams appears feasible by 1995. Related star camera activities are currently underway at the Lawrence Livermore National Laboratory for the Clementine Project and it is hoped that lessons learned there can be applied to the Pluto mission. As a reserve against the possibility that micro star cameras may prove inadequate or difficult to qualify for Pluto, the 1993 baseline Attitude Control System mass rose to 6.65 kg.

Additional savings in mass and power consumption are currently being investigated in the breadboard stage elsewhere for a low-mass inertial reference unit, while test and design qualification activities are planned for the micro star camera.

Spacecraft Data

The Spacecraft Data subsystem includes the central computer and its memory, the mass storage memory, and the necessary input/output devices for gathering data from and commanding other subsystems. The computer executes algorithms for attitude control, sequencing, propulsive manoeuvres, fault protection, engineering data browse and reduction, and other data management functions. The mass memory is used to store all of the near encounter science data for transmission to Earth post-encounter, and to store engineering data between ground communications cycles during the entire mission. In the 1992 baseline the subsystem had aggressive mass and power targets of 7.0 kg and 6.0 W during encounter. Total science data storage volume was 400 Mbits. Use of advanced technology in electronics packaging and low power interface drivers allowed a small mass reduction for the 1993 baseline design while increasing science data storage volume to as much as 2 Gbits.

Structure

The Structure subsystem includes the primary and secondary structure of the spacecraft, electrical and data busses, and separation systems. The structure must support all of the spacecraft components during the vibration and acceleration of launch and injection by the upper stages. The structure helps shield the electronics from the natural and power system-induced radiation environment. The 1992 baseline featured an all aluminum primary structure with a mix of aluminum and graphite-epoxy composite members in the secondary structure utilizing technologies with proven procedures and processes in space applications.

The ATI contractor delivered a prototype composite bus structure weighing 5.7 kg, allowing the structure subsystem mass to drop from 20 to 14.6 kg in the 1993 baseline. This structure is undergoing acoustic testing.

Propulsion

The propulsion subsystem consists of a monopropellant hydrazine thruster set for providing the required trajectory corrections, plus cold-gas thruster attitude control equipment. A hybrid, blow-down system was adapted using a portion of the hydrazine tank pressurant gas as the working fluid for the cold-gas thrusters.

Principal objectives for the Propulsion subsystem design are reductions in subsystem mass, gas leakage, and power consumption. The miniature cold-gas thruster approach meets the thrust, response time, and minimum impulse bit requirements for the Pluto mission and the gaseous nitrogen exhaust minimizes potential spacecraft impingement problems.

From industry input, it became apparent that reductions in mass up to factor of five could be realized in several components. Miniaturization of the pressure regulators and valves (service and latch), use of a composite over-wrapped pressurant/propellant tank as used in the fourth stage of the air-launched Pegasus, and a surface tension propellant management device were identified as technologies of interest for the Pluto mission. Also identified was a miniature (0.0045 N) cold-gas thruster with improved internal leakage (factor of ten decrease) and cycle life (a 29,000-cycle increase) specifications with a wider operating temperature range specification. Thruster valve actuation and holding power would also both be reduced. Based on prototype hardware completed for Pluto, a mass reduction from 20.1 to 9.9 kg appears achievable.

With improvements in the injection accuracy - through 3-axis stabilization of the upper stages plus reductions of the rest of the spacecraft mass - a reduction in the mass of hydrazine monopropellant from 24.6 to 6.9 kg is possible.

Thermal Control

This subsystem is basically passive, consisting of blankets, louvres, radiators, and other thermal paths and insulators. The radioisotope power source provides heat to the ΔV thrusters and is situated to help keep the spacecraft warm during cruise. Multilayer insulation blankets minimize undesirable thermal energy transfer between elements of the spacecraft. Thermal conduction control, such as the thermal isolation between the spacecraft and the antenna, and thermal enhancement allowing more effective energy conduction from the electronics to radiators that are designed to transfer excess heat from the power system, keep all the subsystems within tolerable temperatures. Mechanical louvres actuated by a bimetallic device have good radiative properties in the open position and help to hold heat in when in the closed position. The "thermal zoning" design of the spacecraft eliminates the need for small, separate radioisotope heater units, and minimizes the need for controllable electrical heaters.

In the 1992 baseline design, the mass of the subsystem is 4.0 kg. Power consumption will not exceed 1 W for heaters. The use of advanced technology, like high conductivity coatings and structural materials, may help to reduce the mass and decrease the temperature transients experienced by the subsystems. Subsystem mass has been reduced slightly, to 3.7 kg, from the 1992 baseline.

References

1. S.A. Stern, "The Pluto-Charon system," in G. Burbidge, D. Layzer, and J.G. Phillips, eds., *The Annual Review of Astronomy and Astrophysics* (1992), Annual Reviews, Inc., Palo Alto, CA, USA, 1992.
2. E.F. Young and R.P. Binzell, "Comparative Mapping of Pluto's Sub-Charon Hemisphere: Three Least-squares Models Based on Mutual Event Light Curves," AGU/Montreal, and *Icarus*, 1993.

(See Part 2 of this article, entitled 'Trajectories and Spacecraft Development' to appear in a forthcoming issue of ***Spaceflight****.)*

'Cratered Bodies' Competition

In the last 25 years, spacecraft have systematically extended exploration of the Solar System from Mercury out to Neptune. One of the results of this work has been to show that it is not only our own Moon that has a heavily cratered surface but other bodies (planets and satellites) as well. This month's competition offers readers an opportunity to brush up on the features of some of these other bodies.

Prize: The first correct entry to be opened after the closing date of 7 April 1994 will receive a copy of the book:

The Next Step in Physics *- Chemistry and Astronomy*
by Alan H. Grundy

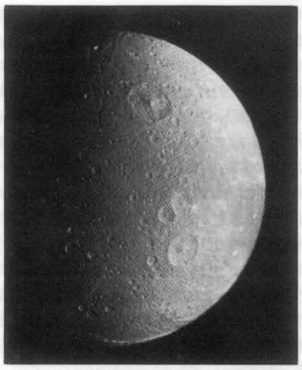
The runner up will receive a copy of the book:

Star-Hopping for Backyard Astronomers
by Alan M. MacRobert

Three consolation prizes are offered of the book:

Citizens of the Sky
by BIS Fellow Bob Parkinson

To Enter: Match up the following photographs with the names in the list below: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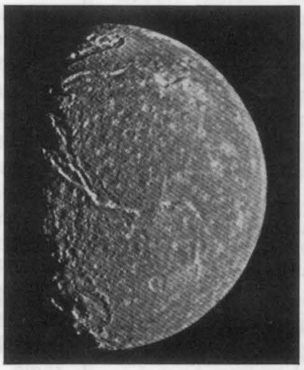
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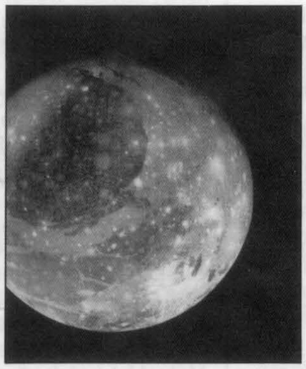
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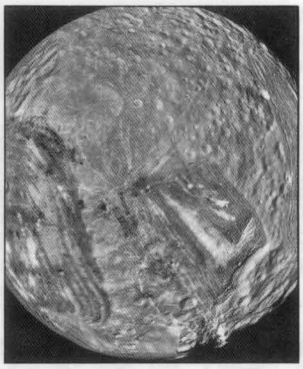
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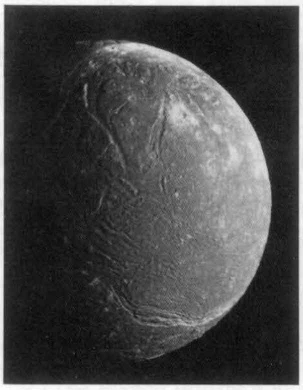
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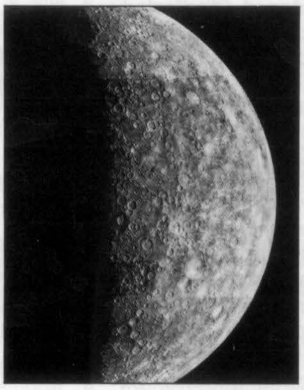
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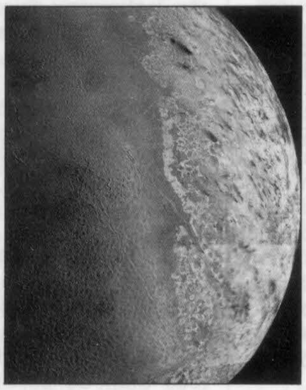
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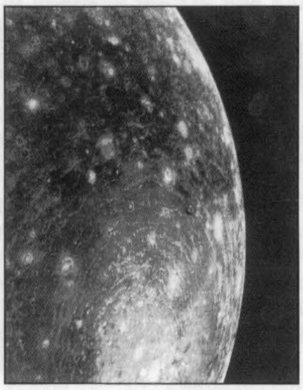
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ENTRY FORM

Picture Name

1. .... 5. ....
2. .... 6. ....
3. .... 7. ....
4. .... 8. ....

Name List: Ariel, Callisto, Dione, Ganymede, Mercury, Miranda, Titania, Triton.

Title/Name ....
Address ....
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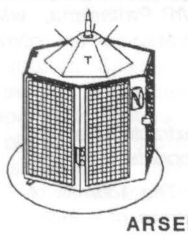
Post to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, to arrive by first delivery on 7 April 1994.

'Find the Spacecraft' Competition Winners


ARSENE

The correct answers are:

SATCOM, SALYUT, ARSENE,
COSMOS, RESURS, GALAXY,
METEOR, LAGEOS, HIPPARCOS,
DISCOVERY, ENDEAVOUR

Winners to whom prizes will shortly be dispatched are:

Mr R. Caruana	Malta
Mr T. Cools	Belgium
Mr N.C.R. Dinnen	UK
Mr R. Jarvis	UK

A View of the Universe

D.F. Malin, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1993, 266pp, £24.95.

This book features a fine collection of colour photographs of nebulae, star clusters, galaxies and galactic clusters, with 60 of the pictures being published for the first time.

After describing advances made in astronomy via photography, the author launches on a tour of the Universe, as seen through his camera lens. Pictures of star clouds and the Milky Way lead naturally to star formation. This is followed by a description of the life history of stars and ends with spectacular pictures of supernovae remnants.

The section on galaxies begins with the Magellanic Clouds and progresses to active galaxies, interacting galaxies and remote clusters in the far realms of the cosmos.

An unusual and interesting feature is that the astronomical objects depicted are as seen in their natural colours i.e. as they would appear if the eye was more sensitive, rather than 'false' colour as is normally the case.

The Cambridge Eclipse Photography Guide

J.M. Pasachoff and M.A. Covington, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1993, 135pp, £10.95.

Solar eclipses are spectacular because of the happy coincidence that the Moon is both 400 times smaller than the Sun and 400 times closer to the Earth. The result is that, when the Moon passes in front of the Sun, it blocks out the Sun almost exactly. However, should the Moon be at a relatively distant part of its orbit, it appears smaller and unable to cover the Sun completely, hence the "ring" of an annular eclipse.

This book describes how and where to observe and photograph the solar and lunar eclipses scheduled for the 1990s. Particular emphasis is placed on the two solar eclipses likely to prove most popular i.e. the annular eclipse (where a ring of sunlight is visible around the Moon) visible from the US in 1994 and the total eclipse that passes over Europe on 11th August 1999, best seen in the UK from Cornwall, weather permitting. Unfortunately, this is a relatively short one, with totality lasting less than two and a half minutes.

Maps and descriptions are included to show where to watch all these eclipses and instructions and tips are given on how to see them safely and how to photograph them both with still and video cameras.

For good measure, several earlier eclipse expeditions are also described which encapsulate some of the excitement experienced by those involved.

Currents in Astrophysics and Cosmology

G.G. Fazio & R. Silberberg, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1993, 310pp, £40.

This book focuses, primarily, on cosmic-ray physics, x-ray, gamma-ray and neutrino astronomy and cosmology. All were main research areas of study by Professor Maurice M. Shapiro, whose 75th birthday the collection of articles celebrates.

The section on cosmic-rays, which covers observations from inside the solar system to those of distant radio galaxies, includes early cosmic-ray observations by Professor Simpson, heliospheric boundary studies by Professor van Allen and the origin of very high energy cosmic rays by Professor Fenyves. Cosmic rays in the galaxy and galactic halo are also explored.

The second part, on x-ray, gamma-ray and neutrino astronomy, covers both experimental gamma-ray astrophysics and theoretical studies. Gamma-rays from solar flares are also reviewed, along with the enigma of gamma-ray bursts. Very high and ultra-high energy gamma-ray astronomy is discussed, particularly those emanating from supernovae.

Resources of Near-Earth Space

The University of Arizona Press, 1230 N Park Avenue, Suite 102, Tucson, Arizona 85719-4140, USA, 1993, 900pp, $75.

Parts of the Solar System most accessible from Earth, notably the Moon, near-Earth asteroids and Mars and its moons, are probably rich in materials having a great potential value to humanity.

This book, compiled with the aid of no less than 86 collaborating authors, explores the future possibility of utilising such materials to produce propellants, structural materials, refractories, life-support fluids and other materials on site, and thus considerably reduce the cost of space exploration. It also looks at the idea that these bodies could be valuable sources of materials and energy for use on our own planet, without being environmentally harmful.

This is undoubtedly the most detailed book yet which focuses on such matters. Contributors renew and update such ideas as possible mining applications and producing oxygen in various ways, processing refractory materials and the like. Asteroids receive particular attention and, in the case of Mars, the emphasis is on possible water resource as well as on carbon dioxide utilisation. Along with the Moon, mission and transportation applications of propellant production in-situ are also considered. What is known about the two Martian satellites, Phobos and Deimos, is summarised and the conclusion reached that another unmanned mission to Phobos is essential before any serious planning for future exploration can be envisaged.

Sub-arcsecond Radio Astronomy

R.J. Davis & R.S. Booth, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1993, 451pp, £37.50.

High-resolution radio astronomy is blossoming, with profound contributions, particularly, arising from recent developments.

In this work 16 review articles summarise current knowledge and outline future research in fields such as SiO, OH and methanol masers, parsec- and kiloparsec-scale radio jets, interstellar turbulence and astrometry. In addition, well over a hundred papers describe the latest developments in subjects as diverse as radio stars, the Galactic Centre and gravitational lensing, and present recent advances that will allow the accurate intercomparison of high-resolution radio and optical observations.

The Space Telescope: A Study of NASA, Science, Technology and Politics

R.W. Smith, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1993, 508pp, £16.95.

This paperback version of a book originally published in 1989 describes the history of the massive Hubble Space Telescope venture, constructed at a cost of more than 2 billion dollars, yet seriously flawed in performance owing to imperfections in the construction of its lenses and by solar panels that caused it to shudder when moving from daylight to darkness.

The original edition, which described how a very large-scale scientific enterprise was translated from vision to the drawing board and then to actual construction, was intended to be followed by another volume on the actual HST performance. However, events since the HST launch proved so momentous that an extra chapter has been added to this reprint which gives an account of the immediate aftermath of this event.

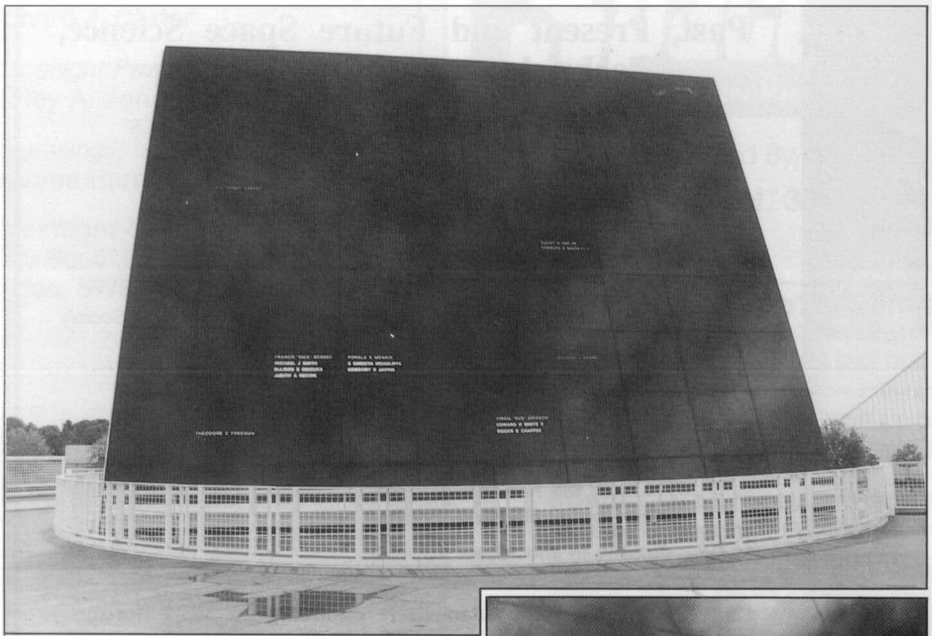
*Readers may also wish to refer to the issue of **JBIS** dated Vol 44, No. 10, October 1991, prepared by staff at the Jet Propulsion Laboratory in Pasadena, which describes various strategies for correcting the HST defects.*

These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

The Astronauts Memorial

BY HOWARD MICHAEL MASON Cheshire, UK

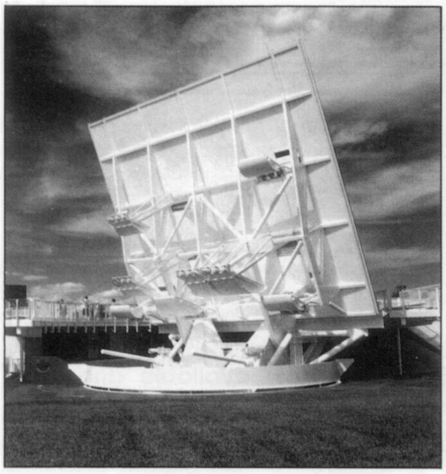


The Space Mirror.
ALL PHOTOS SUPPLIED BY THE AUTHOR

The Astronauts Memorial Foundation (AMF) was set up shortly after the Challenger accident in 1986.

A competition was held for a memorial design which would be built at the Kennedy Space Center, Florida.

In January 1988, the 750 designs were judged and the winning design was chosen.



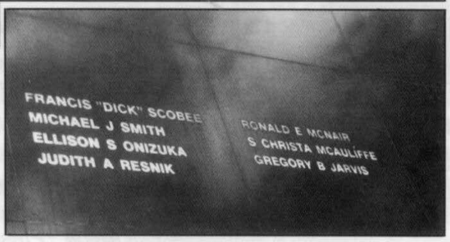
Back view of Space Mirror.

Space Mirror is a 50-foot wide by 42.5-foot-high mirror made of granite.

The design was created by architects Holt, Hinshaw, Pfau and Jones of San Francisco.

The names of the astronauts are lit by sunlight which is collected at the back of the structure in mirrors which focus the Sun's rays through the letter inserts of the names.

Facing the Space Mirror is a smaller structure made up of four granite panels with the words:



WHENEVER MANKIND HAS SOUGHT TO CONQUER NEW FRONTIERS. THERE HAVE BEEN THOSE WHO HAVE GIVEN THEIR LIVES FOR THE CAUSE.
THIS ASTRONAUTS MEMORIAL, DEDICATED MAY 9, 1991 IS A TRIBUTE TO AMERICAN MEN AND WOMEN WHO HAVE MADE THE ULTIMATE SACRIFICE BELIEVING THE CONQUEST OF SPACE IS WORTH THE RISK OF LIFE.

At the foot of this is a panel with the names of the directors of the AMF.

Granite plaque facing the Space Mirror.

At the walkway exit is a circular plaque with fourteen stars and the words:

To Those Who Gave Their Lives To Bring The Stars A Little Closer.
The Astronauts Memorial Foundation Groundbreaking October 11, 1989.

Although I have visited the Kennedy Space Center a few times before, it was the first time I had seen the completed Memorial on this visit.

It was very moving to see such a fine Memorial, knowing that the astronauts who have died in the pursuit of space flight and space exploration will not be forgotten.

The astronauts' names on the memorial are shown in the table below.

Astronaut	Born	Died	Cause
Theodore C. Freeman	18/2/1930	31/10/1964	T-38 training accident
Elliot M See Jr	23/7/1927	28/2/1966	T-38 jet accident
Charles A. Bassett II	30/12/1931	28/2/1966	T-38 accident with Elliot See
Virgil "Gus" Grissom	3/4/1926	27/1/1967	Apollo 1 fire
Edward H. White II	14/11/1930	27/1/1967	Apollo 1 fire
Roger Chaffee	15/2/1935	27/1/1967	Apollo 1 fire
Clifton C. Williams Jr	26/9/1932	5/10/1967	T-38 jet accident
Major Michael J. Adams	5/5/1930	15/11/1967	X-15-3 accident
The 51-L Challenger Crew			
Francis "Dick" Scobee	19/5/1939	28/1/1986	
Michael J. Smith	30/4/1945	28/1/1986	
Ellison S. Onizuka	14/6/1946	28/1/1986	
Judith A. Resnik	5/4/1949	28/1/1986	
Ronald E. McNair	21/10/1950	28/1/1986	
S. Christa McAuliffe	2/9/1948	28/1/1986	
Gregory B. Jarvis	24/8/1944	28/1/1986	
M.L. "Sonny" Carter	15/8/1947	5/4/1991	Passenger aircraft crash*

*At Brunswick, Georgia. At the time, Carter was in training for mission STS-42.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: All Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Admission is by ticket only. Members should apply in good time enclosing a sae. Subject to space being available each member may also apply for a ticket for one guest.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

16 March 1994 — 7 - 8.30 pm

Picometers, Photons and Gravity Waves: The Uses of Interferometers for Space-Based Astronomy

W.I. McLaughlin

Modern technology now allows the light-management techniques of interferometry to be fully implemented in a space setting. Precision measurements of celestial positions can reveal both the architecture and the dynamics of celestial ensembles, and razor-sharp images can also be synthesized. In addition, the detection and analysis of gravity waves is feasible through interferometric methods. Techniques and proposed missions will be discussed.

6 April 1994 — 7 - 8.30 pm

Space Policy

Frances Brown

This talk will focus on the different external factors that have always shaped space policy formulation - sometimes to the detriment of scientific objectives - and will look at how current space policy is being affected by political change and economic conditions, using the developments taking place in various countries' space programmes as examples.

1 June 1994 — 7 - 8.30 pm

The Microlight Solar Sail

C. Jack

Sunlight exerts less than one kilogram force per square kilometre. Deploying and controlling the large area of fabric necessary to convey a conventional spacecraft would be hard. This is why, despite the potential of the idea, no such craft has actually been launched.

Recent advances in microelectronics make possible a quite different concept: a tiny rigid sail just a few metres in diameter which could be controlled purely by electronics, without moving parts. The key components of the craft will be a tiny CCD camera developed at Edinburgh University which can act as both attitude sensor and data gathering device, high performance solar cells providing a few watts of power for control and communication, and a radio which uses the sail itself as a directional antenna. Several attitude control methods are feasible.

The craft will be highly manoeuvrable compared to a large sail and capable of progress under its own power from a low initial orbit. It can thus be launched as a 'piggyback' payload at very moderate cost. It will nevertheless be capable of some ambitious missions, including in particular rendezvous with near-Earth asteroids.

6 July 1994 — 7 - 8.30 pm

Life Support in Space and Lessons for Earth

R. Huttenbach

The talk will describe the features of systems used to sustain astronauts when they live in space. These include the revitalisation of the air they breath, the supply of water and food they consume, and the management of the waste they produce. All must be integrated into loops that can be open or regenerative. Examples of open loop missions (Apollo, Shuttle) and ones with partially closed systems of life support (Mir and Space Station Freedom) will be presented. Beyond this, journeys into space will require a greater degree of material closure. These will utilise plants and biological components to produce food from recycled nutrients.

The technology of biological life support and the evaluation of how closed a system should, or can be, provide important insights into how we might use resources on Earth.

7 September 1994 — 7 - 8.30 pm

What Must We Change For Low Cost Space: Management, Politics or Technology

C.J. Elliott

Early space programmes were cheap and effective. We have now reached the position where a mission like Envisat takes 15 years and costs 1500MAU, justified on the grounds that large missions bring an economy of scale. This lecture examines the drivers that force up the costs of space missions and seeks different ways of behaving that might lead to a virtuous spiral of falling costs and shorter development programmes.

6 October 1994 — 7 - 8.30 pm

The First Manned Lunar Landing Spacecraft: Its Design, Manufacture, Ground Test and Mission

R. Fleisig

This paper uses the development, production, testing and flight of the first successful manned lunar landing spacecraft as a point for current studies of future spacecraft used for a return to the Moon. Described are the Saturn V launch vehicle and the Apollo spacecraft. Apollo trajectories are identified for each mission phase and lunar surface temperatures and other factors considered.

SYMPOSIA & CONFERENCES

4 June 1994 — 10-4.30 pm

Soviet Astronautics

Authors wishing to present papers should contact the Executive Secretary.

Advance Registration is necessary.

Registration: Forms are available from the Executive Secretary. Please enclose a sae.

23 June 1994 — 10-4.30 pm

Space Industrialisation as a Response to Global Threats

Some of the papers to be presented at this Symposium include: 'Space Industrialisation as a Response to Global Threats - An Overview', 'The Exploitation of the Moon to Substitute Terrestrial Resources', 'Sub-Orbital Tourism - The Key to Space Industrialisation'.

Offers of further papers would be welcome. Please send Title and Abstract to the Executive Secretary.

Advance Registration is necessary. Limited student concessions available on request.

Registration: Forms are available from the Executive Secretary. Please enclose a sae.

15 September 1994 — 10-4.30 pm

Space Transportation and Infrastructure

This one day symposium will include papers on 'The Skylon Spaceplane', 'The Architecture of the Space Infrastructure with Advanced Spaceplanes', The Role of Demonstrators in the Development of Reusable Space Transportations Systems', 'The Spacecab Low Cost Spaceplane - An Update'.

Offers of further papers would be welcome. Please send Title and Abstract to the Executive Secretary.

Advance Registration is necessary. Limited student concessions available on request.

Registration: Forms are available from the Executive Secretary. Please enclose a sae.

LIBRARY

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

ASTRONAUTICA AD PACEM HOMINUMQUE PROGRESSUM IAF

45th International Astronautical Congress

"Space and Cooperation for Tomorrow's World"

9 - 14 October 1994, Jerusalem, Israel

The 45th Congress of the International Astronautical Federation will be held in Jerusalem, Israel, October 9-14, 1994. There are 98 technical sessions planned. Proposals for papers are currently being accepted. Deadline for submissions March 1, 1994. To receive the Call for Papers please contact the IAF Secretariat, 3-5 rue Mario Nikis, 75015 Paris, France. Tel. (33 1) 45 67 42 60, Fax. (33 1) 45 73 21 20.

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JOIN THE BRITISH INTERPLANETARY SOCIETY

When you join the British Interplanetary Society
Spaceflight will be mailed directly to your home address each month, hot off the press.

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This offer includes a choice of FREE GIFTS viz: official Society pin-on lapel badge, a voucher that entitles you to £5 OFF any title in the BIS Video Collection or a copy of the 218pp book *Citizens of the Sky* by R.C. Parkinson.

APPLICATION FOR MEMBERSHIP OF THE BRITISH INTERPLANETARY SOCIETY

I apply for Membership which will include a subscription to ***Spaceflight*** and one of the following special offers:

a voucher worth £5 off the price of any title in the BIS Video Collection ☐ *
or an official Society pin-on lapel badge ☐ †
or a copy of the book by Robert C. Parkinson "Citizens of the Sky" ☐ †

I enclose £38 (US$69) for a 12 month subscription from January-December 1994

A special reduced rate of £26 (US$47) is available for those under 22 or over 65 years on 1 Jan 1994.

Full Name (please PRINT surname first)	Title
Postal Address	Date of Birth
Professional Affiliation & Address (if applicable)	Job Title or Position
Signature Date	*Application constitutes acceptance of the Society's Constitutional Rules*

Send to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England

NB Videos available in VHS PAL format only.   *Offer closes 30 June 1994.   † While stocks last.

A Publication of the British Interplanetary Society April 1994 Vol. 36 No.4 US$3.50 £1.90

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NEW !!

SPACE '93 Satellite Link-Up

Arthur C. Clarke on Video

A 50 minute video of Arthur C. Clarke describing his work - past, present and future.

A fascinating, informative chat by Arthur as he responds to questions put by BIS members at the Society's 60th Anniversary Meeting on 17 October 1993.

The question and answer session is led by astronomer and "Sky at Night" TV personality Patrick Moore and by lunar astronaut Buzz Aldrin.

A lasting and entertaining record of a unique occasion and an insight into the stimulating and imaginative world of Arthur C. Clarke.

The video pictures are exclusively of Arthur C. Clarke, with audio presentations by other participants.

Price: £9 (US$16) plus p&p.
Postage and packing: £1.25 in the UK £2.50 (US$5) surface mail overseas.

To place your order please send your remittance to:
The British Interplanetary Society,
27/29 South Lambeth Road,
London SW8 1SZ.

STS-49 Mission Highlights

The details of this flight by the Shuttle Endeavour, 7-16 May, 1992, are well covered, e.g. the preliminaries of suiting-up, the White Room, entry to orbiter, removal of gantry, count-down, engines start, lift-off, and detailed operations during the flight. A principal aim was to retrieve the Intelsat VI satellite which had previously failed to reach synchronous orbit. Though more difficult than expected, it was achieved and sent on its way. A second aim was to practice basic space station assembly work by Extra-Vehicular Activity (EVA). *1hr 50 mins*

STS-46: Mission Highlights

This features the 12th flight of Atlantis with a crew of seven. Flight objectives included the deployment of the European Recoverable Satellite (Eureca) using the Robot Arm operated by Mission Specialist Claude Nicollier and the first, though unsuccessful, launch of a Tethered Satellite. *50 mins*

STS-54: Mission Highlights

The flight of Endeavour with a crew of five features splendid scenes of the launch of theTracking and Data Relay Satellite (TDRS) against an Earth backdrop and experiments with Biopack. Onboard crew activities include a variety of physical exercises. The video concludes with spectacular EVA and Earth shots. *50 mins*

Apollo Missions 4, 5 and 7

Apollo 4 Mission: Covers the launch of the mighty Apollo/Saturn V unmanned space vehicle which reached an altitude of 11,232 miles. As Apollo 4 climbs toward this peak altitude, a camera pointed out the spacecraft window, records views of the Earth. The Service Module propelled the Command Module into reentry velocity of approximately 25,000 miles per hour. *15 mins*

Apollo 5 Mission: Follows the successful testing of the Lunar Module, the spacecraft in which man will make his first landing on the Moon. Tracking stations around the world track its position with pinpoint accuracy as the Mission Control engineers test the many systems onboard. Lunar Module 1 - not designed to return to Earth - tumbles on through space until destroyed by the atmosphere of the Earth. *17 mins*

Flight of Apollo 7: Records life and work on the first manned flight of the Apollo series. Apollo 7 was designated to make the essential test of the Apollo spacecraft before the ambitious lunar-orbital mission could be attempted. All systems respond perfectly. The first television from space highlights the film. *14.5 mins*

Total running time 46.5 mins

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Five cassettes covering Gemini missions (listed below) may be purchased as a set at the special reduced price of £45 (US$90)

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❑ STS-46: Mission Highlights	£15 (US$27)
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Spaceflight

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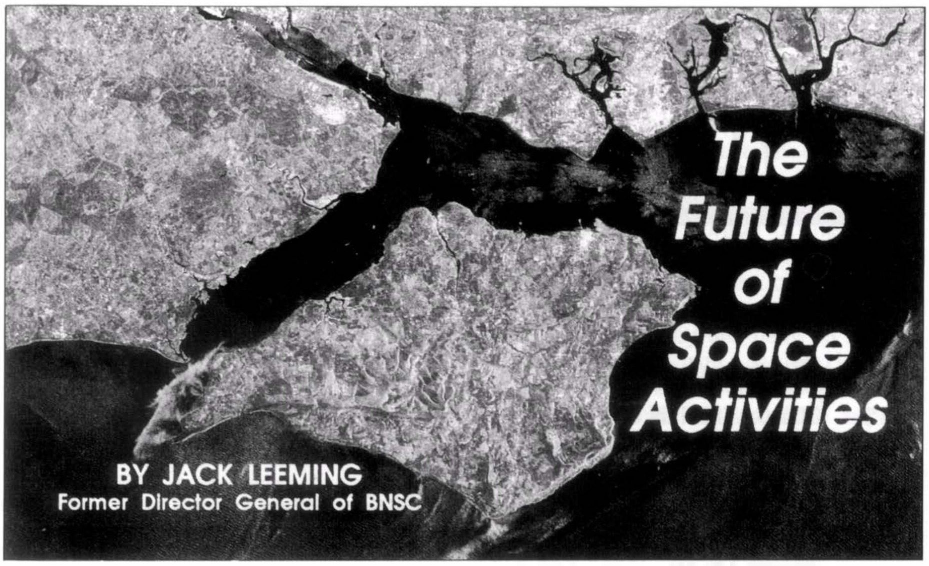
Space Education

Features

News & Events

Space Miscellany

Front Cover: **STS-62 rollout to Pad 39B on 10 February 1994.**
PETER GUALTIERI, WEST KENTUCKY NEWS



ERS-1 SAR image of the Isle of Wight and surrounding area. ESA/MATRA MARCONI SPACE

The space community needs to start afresh to find reasons for exploring and/or exploiting space which will persuade politicians to continue providing public money for future space developments. Where do we look for such justifications for future space expenditure in these difficult times? *Jack Leeming* **attempts to answer this difficult question at a time of changing geo-political and geo-economic climate.**

Private Sector Investment

In the UK, we have long taken the view that we are looking for benefits here on Earth, and most of our funding has been concentrated on space science, communications and, more recently, Earth Observation.

In the case of space science, such benefits are in terms of advances in scientific knowledge and a better understanding of the Universe and/or our own planet Earth. In communications, there has already been almost complete commercialisation with very strong private sector involvement.

In practice we probably need to abandon the word 'commercialisation' because, as related to space activities, it is so misunderstood. For example in the mid-1980s commercialisation was misleadingly applied to the potential benefits from micro-gravity environments in space. There were endless conferences at which the enthusiasts for micro-gravity described 'factories in the sky' leading to major business opportunities before the year 2000. Much of this was to justify Man-in-Space activity and particularly Space Station Freedom, both within the US and also within the 'partner' countries in Europe, Japan and Canada. No one now believes that there are such opportunities within the foreseeable future.

However, we must not abandon the idea of bringing benefits to the private sector as a very important justification for space expenditure simply because the word 'commercialisation' has been abused. In Europe we have successfully involved the private sector in Arianespace, which is presently winning over 50% of the World's commercial launches i.e. those put up for open tender. Similarly, there is every reason to believe that the private sector should be brought in to run the operational Earth observation systems which will be needed in the future, even though most of the customers will be public sector bodies responsible for such things as the environment, agriculture, etc. Many politicians and governments around the world will be discouraged from funding space activities if we cannot find ways of involving the private sector, especially as we move into operational systems.

Technology

Another valid justification for space activities which has sometimes been 'oversold' in the past is the technology involved and the stringent requirements on quality control and reliability. Space is still a new frontier and the most important long term requirement for space is to reduce the cost and risk of launches. To achieve this we will need to change from present launcher systems to horizontal take off launchers which, within the atmosphere, can benefit from aircraft technologies. To do so we will need to improve our materials technologies as well as avionics and computer technologies. These will not only benefit our conventional aeroplane developments but also other industries which depend on the development of advanced material or remote operations (notably the oil exploration and nuclear industries).

International Cooperation

This will probably become an increasingly important factor in deciding upon space activities. Space science has long been carried out substantially on an international basis, but at the other extreme, communication satellites have been developed in a strongly competitive environment, in which the only international cooperation has been amongst the European countries which have developed their competence together within the European Space Agency (ESA). For Earth Observation there are similar national and ESA developments on a unilateral basis, but since the main applications of Earth Observation are international public sector concerns such as the environment, there is a strong case for international agreement on a global basis to co-ordinate the unilateral advances in Earth Observation technologies and in future space missions.

For 'Man-in-Space' missions there was for many years a strong US/Soviet Union rivalry to achieve a dominant role. Since the demise of the Soviet Union the argument has swung the other way. Future Man-in-Space missions, as well as planetary exploration of the Moon or Mars, is likely to depend on international cooperation. The recent US/Russian agreement on space station and other cooperations are now primarily justified on the po-

Kourou: "a launch services production line". ARIANESPACE

Presented as the opening address at the BIS Space '93 Conference, 15-17 October 1993. A version of this article with the same title has appeared in *World Aerospace Technology*.

litical necessity to reduce individual country costs and the political desirability of helping Russia (and the other CIS countries) to obtain economic benefits from the retention of space capabilities developed by the Soviet Union.

Country-by-Country Analysis

The member countries of ESA are already re-assessing their long term programme and re-adjusting the priorities in the light of political and financial pressures in Member States. The Hermes manned space vehicle programme has been virtually abandoned. Priority is being given to Earth Observation - both environmental and meteorological. The future of Man-in-Space activities will depend heavily on the International Space Station project.

Within Europe, France has long had the largest space expenditure and nationally is concentrating on merging their civil and military space programmes. Compared with the US and Soviet Union, European countries have had relatively small military space expenditures, but there is an increasing convergence of military and civil space technologies in both communications and Earth Observation, and the French are increasingly emphasising the importance of the military applications in justifying their national space programme. Their successful civil Earth Observation programme 'SPOT' puts them in a good position on optical Earth Observation systems.

The second largest spender in Europe, Germany, is re-assessing its space expenditure in the light of the affects not only of the world recession, but also the substantial costs of German reunification. In addition to space science, Germany has concentrated a substantial part of its expenditure on launchers and Man-in-Space activities. With the lower priority now being given to Man-in-Space, the Germans are increasing their attention to Earth Observation, but they also maintain a large involvement in Ariane 5 and with future launchers through their national 'Sanger' two stage horizontal take off launcher programme, now more frequently referred to as their hypersonic programme.

The UK, which is now only the fourth largest contributor to ESA after Italy, declined to join the ambitious ESA Man-in-Space programme, concentrating instead on Earth Observation following its earlier concentration on communications. Consequently, the UK has been least affected by the political upheaval on ESA's Man-in-Space activities.

In the United States there is also a fundamental re-assessment of space activities taking place. This again is likely to lead to priority being given to Earth Observation, but the US is also intent on maintaining its leadership in space activities generally. As mentioned earlier, however, Man-in-Space and planetary exploration are likely to depend more heavily on international cooperation, including with Russia. In the past international cooperation by the US has usually been based on a US insistence on NASA leadership with the 'partners' taking a more subsidiary role. With the introduction of Russian involvement in future space stations, it seems likely that the US will have to accept a more equal partnership role. If this is not acceptable within the US it is likely that other countries, not only Russia but also Europe and Japan, will not be prepared to put their faith in NASA leadership in view of the substantial difficulties that have been caused through the US Congress reluctance to provide funding for Space Station Freedom despite the US international commitments to its partners.


A Spot 3 image of Lake Siling-Co, Tibet acquired on 14 November 1993. CNES/SPOT IMAGE

Russia (and the other CIS Republics) have inherited substantial space competence from the erstwhile Soviet Union, but not the economic strength to maintain all of that competence. Sensibly they are re-orienting their priorities from military to civil applications, and especially civil telecommunications and Earth observation applications. Beyond that - for science and Man-in-Space - they too will be looking for an enhancement of international cooperation, and their advances in these areas will depend heavily on the willingness of Western countries (including Japan) to join in international cooperation which will achieve benefits in Russia supportive of their own space objectives (economic, social, industrial and scientific).

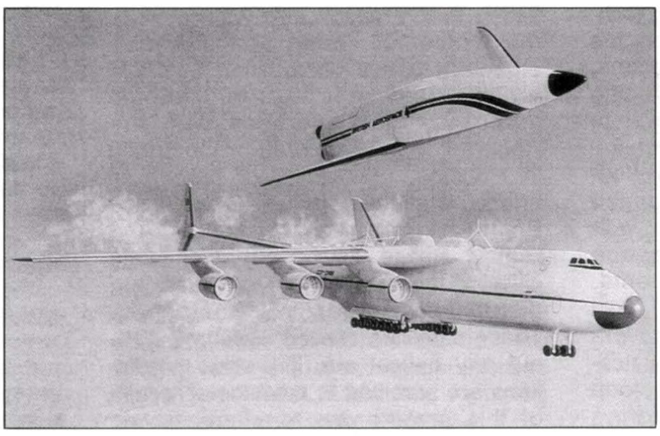

Ariane 5. ARIANESPACE

Conclusion

The future of space activities is likely to depend heavily on the ability of the various space agencies to learn to live within, at best, level funding and, within this, to articulate and carry out programmes which respond to political and economic objectives. This may seem trite to the uninitiated, but in fact space agencies have grown up in a very favoured and protected environment with money readily available to fund a wide range of programmes and, sometimes, substantial overspending on individual programmes. Times have changed.

In the new environment, practical programmes which help to deal with real problems such as pollution etc, (i.e. Earth Observation) are more likely to prosper than Man-in-Space and/or planetary exploration. These latter programmes are likely to proceed at a pace which can be fitted within level funding and can attract sufficient international cooperation.

Artist's impression of INTERIM HOTOL being launched from an Antonov 225. BAe



In the longer term future programmes are likely to depend on the successful development of less costly launches which can provide cheaper access to space. It is a surprise to me that at present so little attention is being given (both in Europe and the US) to the essential technology programmes which need to be undertaken to develop the horizontal type of launcher, which surely will emerge in the next century and provide a great boost to space activities, both commercial and for exploration. ■

Education in Space Applications

Regional Centres for Space Science and Technology to be Established

United Nations interest in the peaceful uses of outer space was first expressed in 1957, soon after the launching of the first Sputnik, and has grown steadily with the advance of space technology. The Organisation's primary concern is that space be used for peaceful purposes and that the benefits from space activities be shared by all nations. The focal point of United Nations action in this field is the General Assembly's Committee on the Peaceful Uses of Outer Space (COPUOS), which was established in 1959. The Committee, which currently has 53 members, reviews the scope of international cooperation in peaceful uses of outer space, devises programmes in this field to be conducted under United Nations auspices, encourages continued research and the dissemination of information on outer space matters and studies technical and legal problems arising from the exploration of outer space.

BY P. LALA
Deputy Chief
Office for Outer Space Affairs
United Nations Office at Vienna

In its early years, COPUOS concentrated on encouraging international cooperation in scientific research programmes, including the International Year of Quiet Sun, the International Indian Ocean Expedition, atmospheric studies using observations of satellite radio beacon transmission, and other research projects concerning the upper atmosphere.

Following the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE) in 1968 and again after the second UNISPACE conference in 1982 (UNISPACE 82), the Committee decided to promote more energetically international cooperation in the application of space technology, particularly for the benefit of the developing countries. The Committee recommended the initiation of a Programme on Space Applications to dispense information on these practical applications and to provide concrete training and education in this field.

The Office for Outer Space Affairs (OOSA) is responsible for the implementation of United Nations resolutions and recommendations of the Committee. The Office, which was recently relocated from New York to the Vienna International Center in Austria, has the dual objective of supporting the intergovernmental discussions in COPUOS and assisting developing countries in using space technology for development. Through the Programme on Space Applications, OOSA organises six to ten training activities each year to assist developing countries in using space technology for economic and social development. These activities are planned and carried out in cooperation with national and international space agencies and host governments, which provide the facilities and most of the funding. The training covers remote sensing, satellite communications, weather forecasting and storm warning, environmental monitoring and basic space science.

During International Space Year 1992, the idea of which was originally proposed by the late United States Senator Spark Matsunaga of Hawaii and subsequently endorsed by the General Assembly of the United Nations, the educational activities of the Programme on Space Application were further extended. For example, young people in all countries of the world were encouraged to conduct nationally, at high school level, an essay contest with the theme "My vision of outer space and the promise it holds for my country and mankind". The aim of the essay contest was to enhance the interest and understanding of the world's youth in space science and technology and its applications. Following local evaluation of the essays, 33 entries were submitted to the United Nations in Arabic, English, French, Russian and Spanish. All leading essays were reviewed by a Board of Editors, and a selection of the ten most interesting ones have been published by the United Nations and distributed among Member States.

As part of the United Nations participation in ISY (also called UN-ISY 92), the Office for Outer Space Affairs organised a live observation of bright artificial satellites for educational purposes. In cooperation with the Rockwell Space Operation Company in Houston, predictions of passes of bright satellites (such as the Space Shuttle, the Mir space station, the Hubble Space Telescope) over large cities of the world were computed and distributed by fax twice monthly. These satellites can be observed without any optical aid, if precise predictions are received in advance. The aim of this project was to stimulate the interest of the general public, and in particular of young people, in space science and technology.

During the International Space Year, 36 planetaria and similar educational institutions in 27 countries participated in this activity. Observations and public response was regularly reported from a number of cities; the most active of these included Brisbane (Australia), Vienna (Austria), Bridgetown (Barbados), Genk (Belgium), Rio de Janeiro (Brazil), Helsinki (Finland), Tel Aviv (Israel), Nagoya (Japan), Wellington (New Zealand), Lisbon (Portugal), Madrid and Pamplona (Spain), Borlange (Sweden), Bangkok (Thailand), and several locations in the continental United States. The response of educational institutions and the general public to this initiative was enthusiastic and in many places predictions were published by local news media.

While most space activities, including those of the United Nations, have focused on the applications of space technology for economic development, space science also makes an important contribution to social, cultural and intellectual development. Planetaria, as educational institutions designed for a broad public of all ages, can make an important contribution to the study and appreciation of the Universe around us, particularly in urban settings where the populations are increasingly cut off from a clear view of the night sky. To help gėnerate interest and support for planetaria in this role, the United Nations, as part of its ISY activities, published a guidebook "Planetarium: A Challenge for Educators". While many major cities already have planetaria, most people in the world do not have ready access to them. In this publication, the experience of people in the establishment and development of existing planetaria has been assembled in order to encourage and guide the establishment of planetaria in regions where they are still scarce or non-existent. The book was first published in English and subsequently been translated into Japanese, Spanish and Slovak.

As a result of the positive responses to the United Nations' activities during ISY, the Committee on the Peaceful Uses of Outer space has recommended that various follow-up activities be undertaken. In the field of space education, the Programme on Space Applications is putting more emphasis on long-term activities, such as fellowships for long-term advanced education at space-related institutions in

various countries. Previous experience has shown that the prospect of educating a large number of people at a reasonable cost is brighter if such a programme is undertaken at the local level. Such a step would require teachers who are familiar with space science and technology and its applications and who can introduce space-related subjects into the educational curriculum in their own national institutions. At present, there is a pronounced scarcity of educators in these disciplines particularly in the developing countries and, at the same time, there is a major need for intensive indigenous capability development in these countries, which can only be attained through long-term educational programmes. Also high on the list of priorities were the need for:

- In-depth education in the fundamentals of the various fields of space science and technology as they relate to sustainable development of natural resources;
- Opportunities to gain experience in a research environment; and
- Access to data and adequate facilities that could be used for processing and analysis.

To facilitate the education process in the field of space applications, the Office for Outer Space Affairs has prepared a proposal for the establishment of regional Centres for Space Science and Technology Education at existing institutions (research or higher education) in developing countries. These Centres shall be teaching and research institutions that are capable of high attainments in the development and transmission of knowledge in the developing countries. Given the global realities and concerns of our time, the initial emphasis of the Centres will be on in-depth education, research-and-applications programmes in remote sensing technology, satellite meteorology and Geographic Information Systems (GIS) for environmental monitoring and natural resources management.

It is envisioned that the Centres will be established in each United Nations region: Economic Commission for Africa (ECA), Economic Commission for Europe (ECE), Economic Commission for Latin America (ECLAC), Economic and Social Commission for Asia and the Pacific (ESCAP) and Economic and Social Commission for Western Asia (ESCWA). Evaluation missions composed of United Nations and outside experts have recently visited several of these regions to survey the situation and to recommend concrete steps for the realisation of the project. The progress thus far achieved has been very promising and it is expected that the first Centre will be functioning in the ECLAC region in a near future and that this will be followed soon after by the Centres in the other regions.

International Space University

1993 Huntsville Summer Session

British delegation and BIS members of the ISU Class of '93 at the shuttle main engine firing test site in MSFC. From Left to right: (standing) Martin Barrass, Nic Mardle, Chris Long, Jason Hatton, Ted Ashburn (BIS, USA), June Morland; (front row) Michael Fick (BIS, Germany), Alex Ellery, Colin Atkinson and Hajime Yano (BIS, Japan).

The International Space University (ISU) is a non-profit international graduate-level institution which teaches all aspects of the peaceful uses of space exploration and development to young professionals and post-graduates from all over the world. It was seven years ago when ISU was founded by a trio of young space enthusiasts at the Massachusetts Institute of Technology (MIT) in the USA in order to identify, assemble, and educate future space leaders. Since the first session at MIT in 1988, ISU has successfully held annual 10-week summer sessions at Strasbourg, France in 1989; Toronto, Canada in 1990; Toulouse, France in 1991; and Kitakyushu, Japan in 1992.

In the summer of 1993, about 100 students assembled at the University of Alabama in Huntsville, USA from 27 countries. During this sixth summer session, 7 British nationals and 3 BIS members participated, studied and worked together in what was a highly international, intercultural and interdisciplinary environment.

BY

HAJIME YANO
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and

JUNE MORLAND
Remote Sensing Group, University College London, London

Academic Curriculum

As its academic schedule was so tight ISU was alternatively referred to as the "Insufficient Sleep University".

There were five categories of curriculum on offer, not including self-study, task group meeting and extra-curricular activities:

- Core Lectures - 88 hrs
- Advanced Lectures - 36 hrs
- Student and Faculty Workshops - 17 hrs
- Plenary/Special Lectures - 12 hrs
- Design Projects - 131.25 hrs

To teach these programmes, more than 120 faculty and visiting lecturers from a dozen nations participate in the summer session each year. This year numerous lecturers also came from NASA research centres. The programme was supported by more than 100 space agencies, corporations, foundations, and individuals in more than 20 countries.

In the first five weeks core lectures were offered aiming at a grasp of fundamentals of all 10 disciplines. Students had to participate in all lectures and pass a written examination covering the entire core curriculum at the end of Week Five. From Week Six, advanced lectures provided up-to-date topics of each department in depth.

At the plenary/special lectures, students learned how differently people perceived space from one culture to another. The Canadian Space Agency President explained how their space activities were developed from scientific interests in aurora while Chinese space development had originated from military technology and the pursuit of national prestige.

Meetings with several astronauts including Dr Jeff Hoffman, who serviced the Hubble Space Telescope in December 1993, was another stimulating

opportunity. Also students enjoyed two discussion sessions with original members of Dr Werhner von Braun's Redstone rocket team. Even in extra-curricular activities, students made a vital contribution. For instance, 33 students gave presentations at the student poster session while the student-organised workshop on space debris attracted an audience of over 30.

After successfully passing all the lecture courses, workshops and design projects, students were presented the Certificate of Completion approved by Dean, Chairman of the Board of Director and Chancellor Dr Arthur C. Clarke at the closing ceremony in Week 10. On 27 August, 98 students of the Class of 1993 joined 719 ISU alumni who are now representing over 50 nations.

Huntsville Community

The Huntsville community was an ideal host site for the ISU summer session in terms of academic resources and close contact with space experts and facilities. The town has the Cummings Research Park, the world's second largest science park, as well as the NASA Marshall Space Flight Centre (MSFC).

Thanks to strong support by the local community, students had many hands-on experiences of American space programmes such as the Space Shuttle main engine firing test and micro-gravity simulation in the neutral buoyancy tank. A MSFC ID badge was issued to each student to meet scientists and visit facilities, which were invaluable for design project development. On Independence Day, all participants received a space flown "Stars and Stripes" flag. Some students gave lectures on their professional topics to teenage campers, including Presidential daughter Chelsea Clinton, at the International Space Camp at the US Alabama Space and Rocket Centre.

NASA had arranged a live link-up between selected ISU students and Astronaut Dr Jim Newman, the first ISU graduate in space, on the shuttle STS-51 which should then have been in orbit. Unfortunately it did not happen due to its record-making six-time launch delay.

Design Projects

There were two design projects in the Huntsville session: the International Lunar Farside Observatory and Science Station (ILFOSS) and the Global Emergency Observation and Warning System (GEOWARN).

Each student had to select one of the two projects and use their expertise in a part of the project. As the session goes by, the complexity of a design project increases and one can witness how a space mission is carried out and what types of expertise are required in each phase. The key to a successful outcome depends upon team work amongst the students and the need to have the best qualified people in the right positions to keep progress on schedule.

At the end of the session, both project teams produced a report in over 300-400 pages and held final presentations at MSFC. This year both projects employed the whole range of expertise with excellent balance, from policy and law makers and architects to scientists and engineers. The details of both projects are described below.

Permanent Campus System and British Involvement

The success of the summer session series has led ISU to establish its Permanent Campus System consisting of a Central Campus and global Affiliate Campuses. A one-year "Masters in Space Studies" programme will start at the ISU Central Campus at Strasbourg in 1995. In conjunction with the 1993 session, the first Affiliate Campus Conference was held with representatives of 22 potential Affiliate Campuses from 13 countries including Cranfield Institute of Technology (CIT) and Oxford School of Architecture from the UK. Also nine UK universities have come together in a consortium to form an affiliate campus network in the future. The consortium partners include: University of Birmingham, Imperial College of Science, Technology and Medicine, University of Kent, University of Leicester, University of Oxford, University of Sheffield, University of Southampton, University College London and CIT.

On 8 November, 1993, the first ISU presentation in the UK was organised by the Space Education Trust (SET), the British liaison to ISU, and the British participants at the Science Museum in London with an audience from government, industry, and private sponsors as well as prospective future applicants. The 1994 summer session will be held at the Universitat Autonoma de Barcelona in Spain; and the Swedish Royal Institute of Technology, Stockholm, Sweden is ready to be host in 1995.

Academic Departments

At the Huntsville session, 9 departments and 1 lecture series were offered and all students belonged to one of the departments listed below:

1. Space Architecture (mission design, space structure)
2. Space Business and Management (business management, finance of large scale international projects)
3. Space Engineering (rocketry, thermodynamics, space vehicle structural design, trajectory, system engineering)
4. Space Life Sciences (physiology, medicine, space biology, psychology, ecology)
5. Space Policy and Law (international law, space treaties, plans and organisations of space agencies, history of space policy)
6. Space Resources and Manufacturing (micro-gravity physics, material sciences, robotics, extra-terrestrial resources)
7. Space Physical Sciences (astrophysics, planetary sciences, plasma physics, Earth sciences)
8. Satellite Applications (remote sensing, satellite communication, geographic information system)
9. Space Humanities (history of space development, space philosophy, space art)
10. Space Informatics Lecture Series (computer networks, data utilisation and management, multi-media, data visualisation technology)

Application Requirements

While applicants may have various academic and professional backgrounds, a bachelor's degree is required. Also applicants should have professional experience of at least two years and/or either hold or currently be enrolled in a Masters or PhD programme in relevant fields. All applicants must be fluent in English, the official language, and at least one more language. Up to 100-130 admissions each year are given to qualified applicants with the following selection criteria:

- academic excellence
- leadership
- internationalism
- commitment to space-related endeavours, and
- working experience in space fields.

British applicants first need to contact SET and an interview will be arranged for the limited number of scholarships. Non-British applicants should look for grants from their national liaisons or the ISU Headquarters' scholarships.

ISU Never Stops Its Challenge

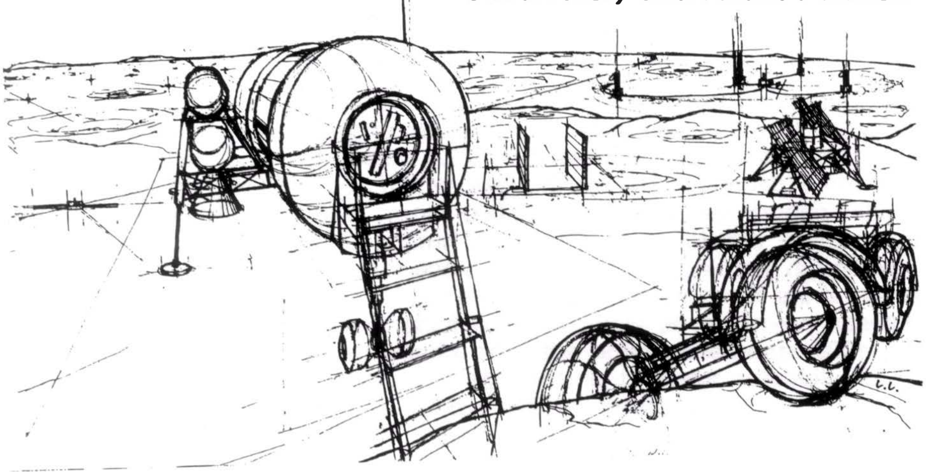
During the cold war, space was a stage for competition between the superpowers. Now the global recession has caused a shortage of big science budgets. Yet space is a final frontier which contains great potential for providing solutions to our global problems such as energy shortage, environmental crisis and population explosion although it still needs fundamental scientific research and long-term investment before we can harvest its fruits.

As seen by examples like the International Space Station and the EURO-MIR missions, world space policy in the 1990's has shifted from competition to what ISU is aiming for, international co-operation. This is why ISU must keep striving for its goal to sustain human destiny in outer space for the next generation and beyond.

INTERNATIONAL SPACE UNIVERSITY

ILFOSS

International Lunar Farside Observatory and Science Station



An artist impression of the ILFOSS facility on the farside of the Moon including the habitat and the Optical Interferometer.

The International Lunar Farside Observatory and Science Station (ILFOSS) is a comprehensive plan created by over 60 young space professionals as the first step toward a permanent human presence on the Moon and as a multi-national scientific project to conduct observations and experiments on the farside of the Moon in order to answer fundamental questions in astronomy, astrophysics and other sciences with the first results to be presented within a decade.

Why Lunar Farside?

The reasons we chose the lunar farside were:

- An ultra-high vacuum with a dark, cold sky to permit superior resolution in all electromagnetic spectral ranges; especially the radio frequencies below 30 MHz being free from the signals of artificial satellites in Earth orbit;
- A stable platform for precise instrumentation;
- A lower gravity suitable for large structure construction; and
- Longer observing times up to 14 Earth day-nights.

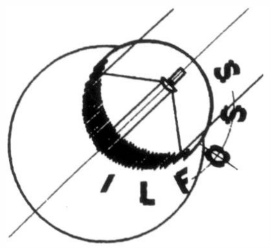
The project is divided into 4 phases: Precursor, Preliminary, Primary and Advanced. No new technologies nor new launch systems were assumed but the whole scenario was derived from scientific, engineering, legal and financial capabilities as of 1993. In 1994-1999, the Precursor Phase employs a lunar polar orbiter to map the lunar surface and select sites for the farside observatory.

Preliminary Phase (1994-2003)

Main objectives of the Preliminary Phase are to:

- Prove the feasibility and scientific advantage of the observational instruments for the Primary Phase,
- Produce significant scientific results at a modest cost (5.3 % of the entire project budget), and
- Demonstrate communication, installation, and long duration operation.

A Delta-II class rocket launches a communications satellite into a halo orbit around the Lagrange 2 Point to



link an Earth ground station with the lunar farside instruments. Five rovers with a 1-m dipole antenna each are deployed from the central station lander to form a small very low frequency array. Another payload is a 1-m diameter UV optical telescope with a navigation beacon for the Primary Phase.

Primary Phase (2002-2020)

In the Primary Phase, the mission objectives are to:

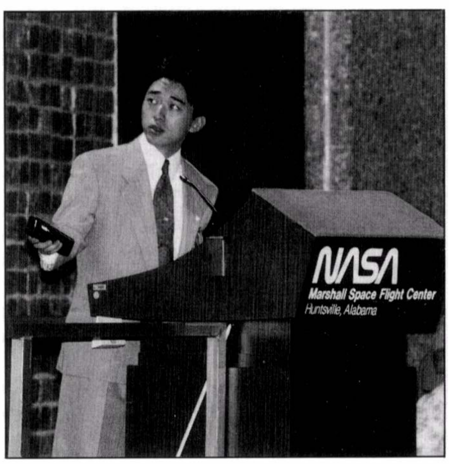
- Perform observations and experiments on leading astronomical and astrophysical questions,
- Conduct unmanned and manned opportunistic research in lunar geosciences, magnetospheric physics, life sciences, material sciences and meteorite and cosmic dust studies, and
- Establish large scale, long term, integrated international cooperation.

More than 90 % of the cost is spent in this phase and the main launching system for payloads is a Titan IV/SRMU. The prime instrument is the Very Low Frequency Array (VLFA), which consists of 300 dipoles with one central station to detect radio signals including those below 30 MHz. The dipoles are deployed from two teleoperated rovers, following a spiral trajectory from the central station lander, in a 17 km diameter region. Observation targets are: the interior of the Sun, the atmosphere of Jovian type planets, active galactic nuclei, supernova explosions and radio galaxies. The second payload is the UV-Visible-IR band Optical Interferometer (OI) formed by three 1.5-m optical telescopes located radially in a 100 m diameter circle and 120° apart. With unprecedented resolution (0.5 milli-arcsec at 5000 Å) compared to the Earth ground and orbital facilities, the lunar farside OI will be directed at pulsars, distant galaxies, external planetary systems, star formation regions, gravitational waves and other unrevealed celestial bodies.

Besides VLFA and OI, there are many other sciences for which the lunar environment can offer an excellent platform. Integrated science packages will be prepared to conduct experiments with small, light, cheap and mostly automated instruments and to produce quick, less constrained but still scientifically important results whenever technically possible. For instance, a fully automated seismometer and X-ray spectrometer will study the lunar surface and interior while an automatic sampling and water production experiment from lunar ilmenite would be a milestone for future lunar resource utilization.

In order to build and calibrate the sensitive OI and conduct more complex secondary sciences, 4 international astronauts will stay on the lunar farside for 42 days after the landing of the cylindrical habitat module. When they return to the Earth, they will bring back lunar material samples as well as retrievable instruments of the integrated science packages such as cosmic and lunar dust collectors and

The author describing the science payloads for ILFOSS in the design project final presentation at MSFC.



biological experiment modules exposed on the lunar surface over several years.

Advanced Phase (2021-)

After completion of the Primary Phase, the Inter-Agency Consultative Group which has led the ILFOSS project will transform to an international consortium "ILFOSS Corp" to conduct the Advanced Phase. The ILFOSS Corp is a company-style organisation like INTELSAT but operated by scientists like the Space Telescope Institute. In this phase, advanced sciences, which require large-scale structures with regular human or robotic maintenance will be addressed. Some candidate facilities are: a gamma-ray observatory, a cosmic ray detector, a 16-m diameter single optical telescope and a very large baseline interferometer with Earth stations. Proposals for observations and experiments would be accepted from all countries and evaluated on merit rather than the financial contribution of participating nations.

Young Rocketeers of the 1930s

The Western Reserve Historical Society History Museum of Cleveland, Ohio is presenting *By Rocket to the Moon*, an unusual exhibition about the Cleveland Rocket Society, a group of high school and college students who, under the direction of their founder, Ernst Loebell, began to design and build rocket motors.

The Cleveland Rocket Society was active in the depths of the Great Depression. The organisation published a newsletter, held meetings and corresponded with rocket societies throughout the world. But most importantly, it conducted a series of significant rocket motor tests. The tests led to several unprecedented developments, including what was probably the world's first regeneratively cooled motor and an electric ignition. These were presented to the world at the Paris International Exposition in 1937.

By Rocket to the Moon exhibits the only surviving original rocket motor and is supplemented by a replica of the CRS's last rocket motor test stand, manuscripts, photographs, and other documentary materials. In addition, the Historical Society was able to find and interview three of the CRS's original members.

Many of these young rocketeers got their inspiration from reading stories by Jules Verne and H.G. Wells. They were also inspired by comic strip characters such as Buck Rogers, and films including Fritz Lang's "Frau im Mond", and H.G. Wells' "Thing to Come". Beginning with early illustrations of rockets and outer space, the exhibit presents the toys, books, magazines, and movie memorabilia that fascinated Cleveland's Rocketeers and the generations that followed. The exhibition is open until June 1994.

GEOWARN

Global Environment Observation and Warning

The increasing world population is causing the toll taken by disasters of all types to increase yearly. The number of people affected by disasters on average per year has risen from 27.7 million to 130.8 million within the last three decades. The earthquake which rocked India in 1993, killing 10,000 people and affecting 150,000 more, is a graphic example of the devastating effects of disasters on human society.

Although warning systems are in place for some disaster types in a few areas, there is no world-wide system for monitoring hazards and issuing disaster warnings. In view of these facts the ISU presented students at the 1993 summer session with the challenge of designing an "international disaster warning and mitigation system". 38 students from 18 countries worked together on this project over a 10 week period and produced a solution known as GEOWARN, Global Emergency Observation and Warning.

GEOWARN Structure

As with other ISU design projects, decisions about the goals and scope of the GEOWARN project were made by students. They decided that the principal goal of GEOWARN is to minimise the effects of disasters on human society. This will be achieved by providing a disaster warning and relief support service. Students designed the initial GEOWARN system to cover the six natural disasters which result in the greatest annual loss of life. In order of severity these are: droughts, insect infestation, earthquakes, crop disease, hurricanes and floods. Since an earthquake warning service is not technically feasible and since there are agencies which already issue hurricane warnings, GEOWARN will provide a warning service for the other four disasters. Data will be acquired from existing meteorological satellites as well as from a constellation of six Low Earth Orbit GEOWARN satellites.

After a disaster has occurred GEOWARN will complement the work of existing relief organisations by providing them with high resolution images of the disaster area. Since satellite sensors cannot yet meet the requirements for high spatial resolution, GEOWARN aircraft will acquire images using optical sensors as well as a Synthetic Aperture Radar. These aircraft will be based at twenty different locations throughout the regions most affected by the fast breaking disasters: earthquakes, hurricanes and floods. Relief teams will receive these images, along with archived information on the affected area, through portable satellite communication terminals which can, of course, also be used to communicate with outside organisations.

Task Groups

The students on the GEOWARN project broke up into four teams. One group concentrated on obtaining information about disasters and their observation, another group worked on the overall system architecture, the third group addressed the data management aspects while the fourth devoted their time to considering the sensitive economic, political and legal issues involved. They estimated that GEOWARN will cost on average less than $500 million per year. Since annual economic costs of disasters are $100,000 million, investment in the system would be justified if it saved only 0.5 % of these costs. GEOWARN will be a non-profit organisation funded by the governments of member countries. As a humanitarian organisation, it will be open to all nations regardless of their political or economic circumstances. Even countries which either cannot afford to or do not wish to join GEOWARN will receive its disaster warning and relief services.

Further Studies Continue

The conclusions reached by the end of the summer session were that there is clearly a need for an international disaster monitoring and relief service and that such a system is both technically and economically feasible. What is lacking at present is the political will to implement it.

The ISU environment is one where students are encouraged to believe that what they do can make a difference. Many of the students who worked on the GEOWARN project are unwilling to see it die with the end of the ISU summer session and are already beginning to promote the concept in several international conferences.

Of all global cooperative programmes, GEOWARN is one of the most logical to pursue because of the potential benefits it offers humanity.

We are pleased to report that NASA MSFC has been pursuing a phase 0 study of it. ■

Space Education at the International Astronautical Federation

The scope of the Education Committee of the International Astronautical Federation, IAF/EC, includes all matters relating to the effects of space activities on the formal and informal processes of education and vice-versa.

The IAF/EC has presently 35 members representing space agencies, industries, universities and NGOs from 14 countries: Australia; Brazil; Canada; China; Cyprus; France; Germany; Italy; Japan; Russia; Slovenia; Ukraine; United Kingdom and the United States.

Committee members meet every year at the International Astronautical Congress organised by the IAF, where they share experiences; present summaries of the activities relating to space education developed by their organisations or countries during the year; and discuss on-going and future programmes. These include:

- Specific student activities and supervised youth research experiments;
- The use for educational purposes of communications satellites;
- Earth observation satellites;
- Manned and unmanned spacecraft and ground-based laboratories;
- The many educational techniques developed to motivate the learning of scientific and other disciplines; and
- The activities of groups intended to raise public awareness of the benefits of space exploration.

The 'Student Activities' and the 'SYRE' subcommittees are part of the IAF/EC. The first of these is responsible for any student-related activity that can be appropriately undertaken by and between the IAF member societies. The SYRE subcommittee focus the attention of educators, training specialists, rocket-club supervisors, and other youth-rocket-science motivators on the problems associated with students gaining "hands-on" extracurricular experience through rocket and space science research experiments conducted as supplements to classroom studies. It promotes supervisor-to-supervisor interaction, necessary for the successful exchange of information - particularly in fields dealing with potentially hazardous materials and procedures - not only through the SYRE sessions at IAF congresses, but also through surveys of available facilities, development of safety recommendations, and dissemination of publications and audio-visual materials.

Every year during the IAF congress, the Education Committee organises and promotes the *Symposium on Space and Education*, that includes three technical sessions:

Hands-on-Education, for the presentation of communications related to practical activities as a way to education in space science and technology;

Education Structures, that shows methods and organisations for the development of space education or space assisted education; and

Communicating with the Public, that presents different aspects of space related arts and communication for developing space awareness in the general public.

BY FABIOLA DE OLIVEIRA
Vice-Chairperson
IAF Education Committee

This last session is jointly organised with the American Institute of Aeronautics and Astronautics (AIAA) and it is traditionally opened by an invited speaker who presents a distinguished lecture named after Alexander Ananoff, organiser of the 1st International Astronautical Congress in 1950.

Last year at the Congress in Graz, Austria, on 16-22 October, the invited speaker was John Allen from the Space Biosphere Ventures, who was responsible for the Biosphere 2 project (Arizona, USA). The three sessions of the Symposium in Graz had a total of 21 communications with authors coming from Australia, Brazil, China, France, Germany, Israel, Italy, Japan, Ukraine and the USA. Also in Graz the Education Committee inaugurated two new activities, mainly devoted to the public understanding of space. One was a meeting with the journalists who were reporting on the Congress, most of them being specialists in space related subjects.

During this first meeting with the media representatives, journalists mentioned that the space sector needs a focus for public attention. They recalled that during the cold war this focus was basically supported by competition and conflict, but now another focus should be to educate people, showing space as a new path for mankind. It was concluded by the end of the meeting that the 1960s and 1970s had fascination as a main focus, but now education is the great challenge to bring positive public attention back to the space sector. The IAF/EC plans to organise a Meeting with the Press every year at IAF congresses.

The other new activity promoted in Graz last year was a Public Outreach Program, that was organised in order to "utilise the capability/resources of the Congress to disseminate to the public in the resident city, the importance and benefits of space as an essential part of our modern world". The public activity included speeches presented by Austrian space specialists, who answered many questions from the audience. Because of the success of this first programme and considering the importance of bringing information related to space activities to the general public, the Education Committee decided to create a *Public Outreach Working Group*, for the purpose of preparing Outreach Programs for the benefit of students and the general public in the host city of the congress.

The *IAF Education Committee Bulletin* is the newsletter of the Committee and it is published twice a year. It brings information on space education initiatives such as seminars, meetings, contests, publications, educational curricular and extracurricular programmes, programmed student activities and short articles. The IAF/EC Bulletin provides a forum for the Education Committee, its Subcommittee members, educators and those interested in international educational cooperation. It provides a place announcing future activities, communicating and coordinating joint activities, making contact with others in the education field and reporting on progress and events. It is open to receive and publish any relevant information concerning space education and the public understanding of space.

Since 1991, the IAF Education Committee has been promoting the *Seminar on the Future of Space Education*, that usually takes place during the month of May. It is organised in two parts, first with an attempt to figure out our future in space, followed by a reflection on what this would mean for space education today. The seminar also includes the presentation of technical papers and/or communications. The 3rd IAF Annual Seminar on the Future of Space Education took place in Mittweida, Germany, on 24-26 May, 1993 with the participation of leading space educators from England, France, Germany, Russia and USA. One of the main conclusions of this seminar was that:

> "Many aerospace organisations who usually support space education suffer today from some kind of recession and education programmes are often the first to feel the pinch. It was suggested that space educators should anticipate future trends and begin to balance and diversify their support sources by establishing new educational relations with the branches of business that are the most deeply involved in environmental issues, i.e. the construction and the energy business".

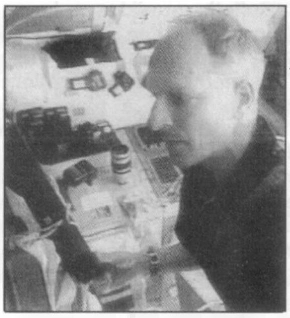
(Report of the Mittweida Seminar, by G. Pignolet). The 4th IAF Annual Seminar on the Future of Space Education will take place in Brazil, at INPE's headquarters, in São José dos Campos, state of São Paulo, on 10-13 May 1994.

At the Graz IAF Congress, the members of the Education Committee elected a new leadership for the period 1994-1995. The Chairman of the IAF Education Committee is now Mr Hans von Muldau, from Germany, and the Vice-Chairpersons are Mr John Whitesides, from the USA, and Ms Fabiola de Oliveira, from Brazil. The editor of the "IAF Education Committee Bulletin" is Ms Fabiola de Oliveira and the publisher is Mr Guy Pignolet, from France.

For those wishing to contact the IAF Education Committee the address of the Chairman is Mr Muldau: PFIAT - Dieburg Strasse 83 - 6101 Rossdorf, Germany - tel: (49) 61 54-9093, fax: (49) 61 54-9092. Contributions for the Bulletin can be sent directly to the editor: INPE/CRI - Av. dos Astronautas, 1758 - 12227-010 São José dos Campos, SP, Brazil - tel: (55) 123 41-8977, fax (55) 123 21-8743. ■

Young Reader Queries Houston Photo Caption

Sir, The other day I was reading the January 1994 edition of ***Spaceflight***, where on page 16 there is an article headed 'Major Role for ESA'. The picture that accompanies it seems to be incorrect. Is this so?



← Aft Panel

Pilot's Seat →

The caption says that astronaut Claude Nicollier is at the controls of the Remote Manipulator System during Hubble's servicing. However the astronaut seems to be behind the pilot's seat and you can see part of the aft panel which operates the actual system in the background.

ELGAR CHAPPEL, age 12
Coventry, UK

Ed: The caption was that supplied by Houston with the photo. Nevertheless we referred the matter to Dr Roelof Schuiling of the Kennedy Space Center, who writes:

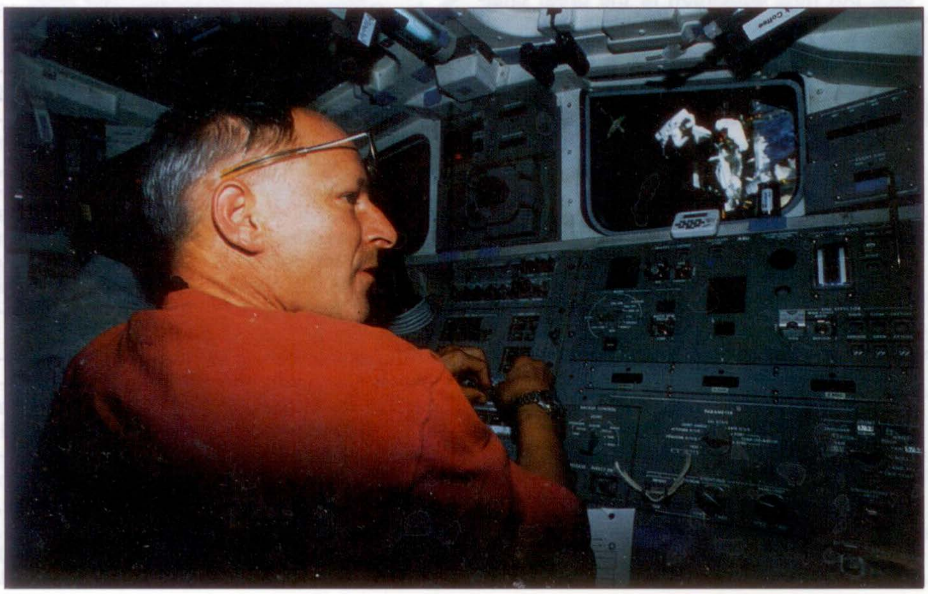
I would agree that the picture is miscaptioned. There are three items of note:

1. The computer screen and keyboard, just forward of Nicollier's chin in the photo is on the right side of the aft flight deck, indicating that the front of the orbiter is to the left and the aft to the right of the picture.
2. The tiny gray triangle just behind Nicollier's head is the juncture of the upper and lower aft bulkhead instrument panels and the curved line of the flight deck roof.
3. If Nicollier were at the RMS operating position, the slanted area shown above his hand would be in the payload Standard Switch Panel area on the left side of the aft flight deck and would not be covered by the array of equipment shown in the photo, whereas if on the right side that area would be stowage and equipment storage as it appears to be in the photo.

My only possible caveat with Elgar Chappell's observations might be that Nicollier appears to be behind the Commander's (the left hand) seat as the Pilot position is the right hand seat. There appears to be some distance from Nicollier's arm to the side panels consistent with this. In any case, Elgar Chappel is to be congratulated on his knowledge and his keen observation.

Ed: Houston has now come up with a new photo of Claude Nicollier in action during the Hubble mission - together with a caption that hopefully sets the record straight.

Claude Nicollier is stationed on Endeavour's flight deck during one of the five Hubble Space Telescope servicing space walks. The controls for the Remote Manipulator System, which played an important role in the space walks, are left of frame centre. NASA



Space Class

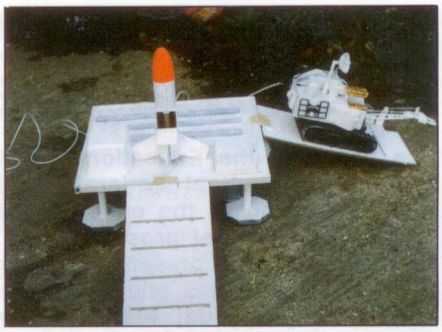
Sir, I am enclosing some photographs of a teleoperations simulation I am pursuing with some of the children at my school.

I have been running an after-school "Space Class" for the past five years. This year, I am arranging a Mars sample return mission for the children to run. Obviously, my resources are somewhat more limited than national space agencies, so I have had to compromise on my materials. Thus the lander pallet is a scrap piece of 2 ft square chipboard, with broomhandle legs, ballcock fuel tanks and ice cream container electronics modules.

Where I *do* score over the big boys is that my lander is already "there"! (in imagination at least).

The rover is a modified toy excavator, to which has been attached a robot arm. The sample return rocket is constructed from Estes components and plastic card with a simple magnetic catch to close the sample chamber.

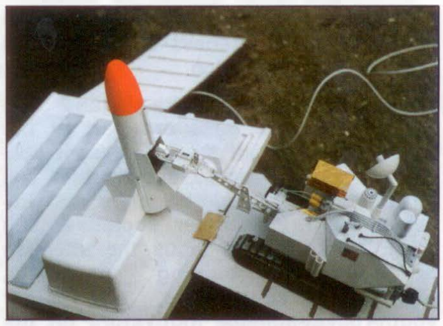
The photographs demonstrate the sequence. The rover is guided off the platform and manoeuvred to the vicinity of the chosen sample. The sample is retrieved using the robot arm and the rover returns to the platform. It then mounts the ramp leading to the rocket, deposits the sample in the chamber and, using its arm, closes the chamber. The rover then withdraws to allow the rocket to take off in the standard Estes manner.



The rover moves off and the rocket hatch opens.

At present all the guiding is done by eye; as soon as funds allow, I shall be attaching a CCD camera to allow a more realistic impression of teleoperations via a monitor.

Different presentations are possible: simple "against the clock" competitions; deciding whether to recover easy samples, or to go for less accessible but more interesting specimens, thus balancing risk against gain; planning routes according to varying criteria.



The rover returns with the sample and places it in the hatch.

The rocket can be replaced with a "sample analyser", connected to a piece of software, which then simulates the discovery of say, lunar polar ice or biological materials on Mars.

Over the years, my school Space Class has done the following projects: Build a Moonbase; Design a Solar System; Make a Moon; Create an Alien; Mars - Fiction and Fact; Build and Fly Rockets (Estes and water-powered).

TREVOR SPROSTON
Herts, UK

Science Project Success

Sir, I would like to thank you very much for all the help and information you gave for my science project.

My project went to the National level and was the highest point scorer. I intend to further my study of space and with the help you provided it encouraged me to do this.

Once again thank you and maybe one day I will work for your association.

ABIGAIL CLARK
Botswana

SAREX - Shuttle Amateur Radio EXperiment

BY FRANK BELL
The Royal Grammar School
Guildford, Surrey

Some shuttle missions carry and operate amateur radio equipment. Interested listeners can monitor the SAREX transmissions and learn some of the latest news. SAREX supports several different modes of transmission; voice, digital packet and SSTV. Anybody with a suitable receiver can listen to the shuttle but to transmit to them an amateur radio licence is necessary.

Not all missions carry SAREX and not all missions come over the UK. The 57 degree inclination orbit that NASA sometimes uses brings the shuttle over the UK and fortunately these missions usually carry SAREX.

STS-60, which was in orbit from 3-11 February 1994, ran SAREX but, as far as I can judge from monitoring every day, only the packet system was running. However this did allow our school to receive messages from STS-60 and they did acknowledge the packet connect requests sent from our school radio station. (Packet communications are a means by which messages entered on a computer keyboard can be transmitted to, and displayed on, another computer via amateur radio signals.)

Voice contact with a shuttle can be made but it depends so much on the work schedules of the astronauts and their willingness to talk to amateurs on Earth. A good example was the STS-56 mission which was extended by one day; with their work completed, the astronauts invited voice contact from amateur stations. I had two 5-minute conversations with them while the shuttle was over the UK.

The best frequency to monitor is 145.550 MHz FM as most of the downlink of the shuttles is on this frequency. To contact them on packet use 144.490 MHz and for voice try 144.700, 144.750 or 144.800 MHz FM.

The next mission to fly SAREX will be STS-59, which is targeted for early April 1994, and its 57 degree orbit will bring it over the UK. Contacts with schools are included in the mission planning and unplanned contacts include the Mir space station and international ham radio operators.

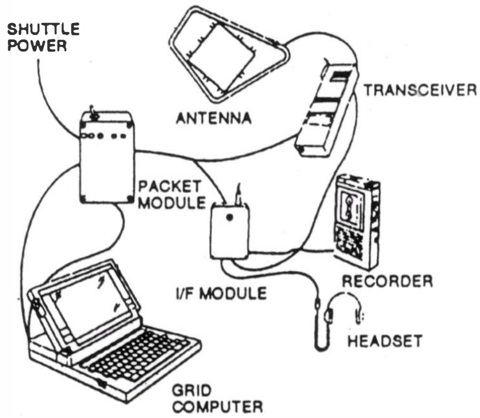
Packet Radio Contacts between The Royal Grammar School and STS-60

W5RRR-1>QST: W5RRR-1 is listening for connect requests on 144.49 MHz. Voice uplink (All except Europe): 144.91, 144.93, 144.95, 144.97, 144.99 MHz. Voice uplink (Europe): 144.70, 144.75, 144.80 MHz.

From onboard the Shuttle Discovery, Good Morning! Our first day was quite hectic, but we're now settling in for lots of work on a very exciting mission.

W5RRR-1>SAREX: This is STS-60 SAREX Robot station W5RRR-1 onboard the Space Shuttle Discovery.

GX7BAI CONNECTED to W5RRR-1 #1149 is your SAREX QSO number.



SAREX-II equipment on board STS-59 will include a low-power, hand-held transceiver, headset, an antenna designed to fit in a cabin window, interface module and an equipment cabinet. **NASA**

W5RRR-1>QRZ: #630-ON1APG G6SVJ PE1MXV OM3CTT PA3ELB PE1OIG ON7EQ OE3EV GX7BAI ON1BC G7BAI PE1OKJ F6DBL G1HWY F6HDW EA7DBP CX9BBF

W5RRR-1>QST: Greetings from the crew of STS-60! Our current altitude is 190 nautical miles above the beautiful Earth that is the home for all of us. We are very busy with Spacehab experiments and hopefully today we will deploy the Wake Shield Facility. Best wishes and poka! Private to MIR crew.

W5RRR-1>SAREX: This is STS-60 SAREX Robot station W5RRR-1 onboard the Space Shuttle Discovery.

W5RRR-1>QST: Greetings from Discovery on our sixth day in orbit. We enjoyed a conversation with President Clinton while he was visiting Houston Mission Control yesterday. This morning we talked with our colleagues on Mir via satellite and we hope to talk with the Mir cosmonauts today with SAREX. Thanks for your interest and support of our flight. Best wishes from the crew of STS-60.

W5RRR-1>SAREX: This is STS-60 SAREX Robot station W5RRR-1
onboard the Space Shuttle Discovery.

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-59	7 April	Endeavour	9 Days	SRL-1, Concap-IV, GAS	57.0
STS-65	July	Columbia	13 Days	IML-2	28.5
STS-68	August	Endeavour	9 Days	SRL-2	57.0
STS-66	September	Atlantis	10 Days	Atlas-3, Crista-SPAS, SSBUV/A	57.0
STS-64	September	Discovery	9 Days	LITE, GBA	57.0
STS-67	December	Columbia	13 Days	ASTRO-2	28.5
STS-63	January	Discovery	8 Days	Spacehab-3, Spartan-204, CGP/Oderacs-2	51.6

Junior WeatherSat

Weather Satellite Image Acquisition System for Education

Junior WeatherSat was launched in January 1994 with demonstrations of live satellite receptions at the National Hall in Olympia, London during BETT '94.

The design of the Junior WeatherSat system is based on the original award winning MacSat II image acquisition system and is targeted at the education market. The system receives, processes, analyses and displays live pictures of the Earth from space and, with little or no knowledge, students can interpret weather formations as they happen.

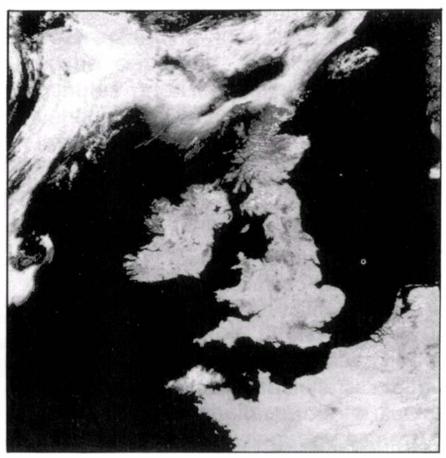
The system is a product of Newcastle Computer Services plc and is marketed in three configurations:

1. Geostationary only, e.g. Meteosat and GOES
2. Polar orbiting only, e.g. NOAA and Meteor
3. Full system.

Options 1 and 2 are both fully upgradable to the full system. Technical support takes the form of: Monthly prediction data; Regular news bulletin; Half price charges for on-site work; Telephone hotline; Updates on satellite movements and developments; and Worldwide sample images available on request.

The system has been written up by teachers for teachers and has many additional features.

A Junior WeatherSat image of the British Isles. The system is available under both platforms: Macintosh and MSDOS/Windows.



Ausroc II on the launch rail at Woomera.

The Australian Space Research Institute is an amateur organisation composed of space and rocketry enthusiasts and was formed when two amateur Australian groups, "Ausroc Projects Group" and "Australian Space Engineering Research Association", merged. This gave the groups the advantage that any donated funds would be tax deductible, being used for official "Scientific Research" as defined by Section 73A of the Australian Income Tax Assessment Act. The institute is 'government recognised' and has the aim of promoting space related research, science and education and of giving Australian students, engineers and scientists experience in the area of rocket design, development and research. The group is now conducting research into micro-satellite engineering, supersonic ramjet propulsion and rocketry.

ASRI Objectives

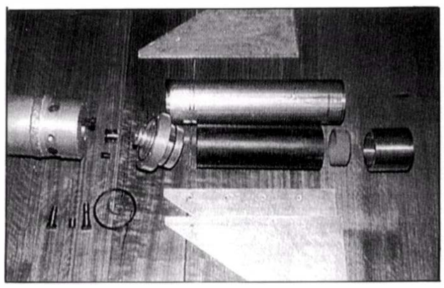
- To develop and advance space science and technology.
- To conduct, encourage and promote research in the field of space science and technology.
- To educate and extend knowledge in the field of space science and technology and to make available educational opportunities to supplement and further those provided by established educational institutions.
- To conduct, co-ordinate and support projects for the advancement of space science and technology.

Ausroc I

Ausroc Projects Group (now under the aegis of ASRI) was started in 1988 by a group of students at the Monash University in Victoria and a number of Australian amateur rocket enthusiasts with the intention of building a liquid-fuelled rocket. Their first rocket, the Ausroc I, was a rocket from the Pacific Rocket Society modified to carry an electronics package and parachute recovery system. Launched in February 1989, it achieved a burnout velocity of 600 km/h and an altitude of 3.5 km. The recovery system failed and the rocket was lost. The organisation is now building another rocket of the same design, with improved instrumentation and recovery system. They call this the Caratel.

Ausroc II

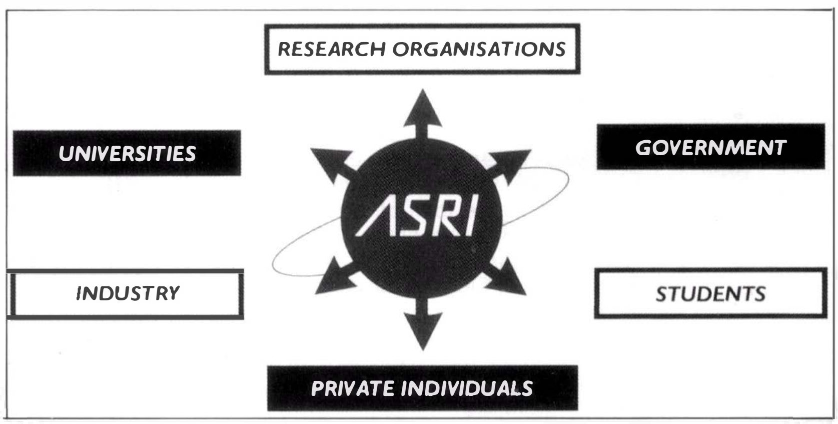
Soon after the launch of Ausroc I, a bigger and more ambitious rocket, the Ausroc II, was designed and built solely by amateur enthusiasts and university students with small corporate sponsorship. This vehicle was a liquid-fuelled bi-propellant rocket using kerosene and liquid oxygen (LOX) and weighing 225 kg. It measured 6.1 metres in length and 0.258 metres in diameter, making it one of the largest amateur rockets ever constructed. It was to have reached an altitude of 12 km with a burnout Mach number of 1.6. Unfortunately, there was an accident when it was launched and the rocket was partially destroyed. This was the result of the LOX valve failing to fully open on time. The fuel line and kerosene valve worked and the kerosene flowed freely and burned inside the rocket without giving any significant thrust. This caused extensive damage to the vehicle. Current plans include the launching of an improved Ausroc II, using parts recovered from the first rocket. The 11.5 kN main rocket engine has been salvaged but the main rocket structure and fuel tanks have had to be totally rebuilt. This has been made possible through a generous donation from the Australian Space Office. The group estimates that another $6000 is necessary to bring the vehicle up to launch readiness. The launching of the Ausroc II-2 is targeted for mid-1994 at the Woomera rocket range in South Australia.



Exploded view of Caratel.

Disciplines

- Liquid, solid and hybrid rocket propulsion systems
- Guidance and control systems
- Composite and light weight structures
- Launch site development and operations
- Aerodynamic testing and analysis
- Flight safety systems
- Spacecraft structures
- Space qualified electronics



Disciplines

- Simulation and modelling
- Supersonic airbreathing propulsion technology
- Systems engineering methodologies
- Power systems
- Telecommunications
- Distributed computer systems
- Autonomous control systems
- Instrumentation and telemetry systems
- Imaging systems
- Software engineering

Ausroc III

Design and construction of the Ausroc III vehicle have now begun. This will be a liquid-fuelled rocket, using kerosene and liquid oxygen. The Ausroc III programme has a primary objective of building a rocket capable of lifting a payload of 100 kg to an altitude of 500 km and recovering both the rocket and its payload intact.

The rocket will be by far the largest amateur rocket ever constructed. Three types of propulsion were initially considered for the rocket, namely solid fuel, hybrid (liquid oxidiser, solid fuel) and liquid fuel. While hybrid fuels are considered the safest rocket fuel types, they are still in the research stage and as little data relating to them was available they were rejected. They were also rejected on account of expense. Solid-fuelled rockets are the cheapest and simplest form of rocket available today, but Australia does not yet have the capacity to cast the 1200 kg of solid propellant required. Thus solid fuels were also rejected. Liquid fuels were chosen because of their extensive developmental history, relative safety and low cost.

Models of Ausroc I, II, III and IV.

Standing 8.4 metres tall and 70 cm in diameter, the rocket will be the most complex amateur rocket ever constructed. It will be controlled by a commercial 80386 microprocessor. The rocket will be navigated through the use of a strapdown inertial navigation unit consisting of 3 accelerometers, 3 gyros and possibly a GPS satellite terminal. The rocket's trajectory would be monitored by a variety of methods ranging from accelerometers to radar. Telemetry from the vehicle's 128 sensors would be relayed through a 5W L-band radio transmitter.

It will carry 836 kg of LOX and 348 kg of kerosene to be fed into an engine at the rate of 14.8 kg/s at a mixture ratio of 2.4 (oxygen/fuel) to generate a thrust of 35 kN. Rather than using expensive and heavy fuel and oxidiser turbopumps, the fuel will be supplied using an innovative pressure feed system. Pressurised helium will keep the fuel tanks at a constant pressure of 3MPa for the 80 second duration of the rocket burn. The engine will use a two-axis electro-hydraulic gimbal steering system.

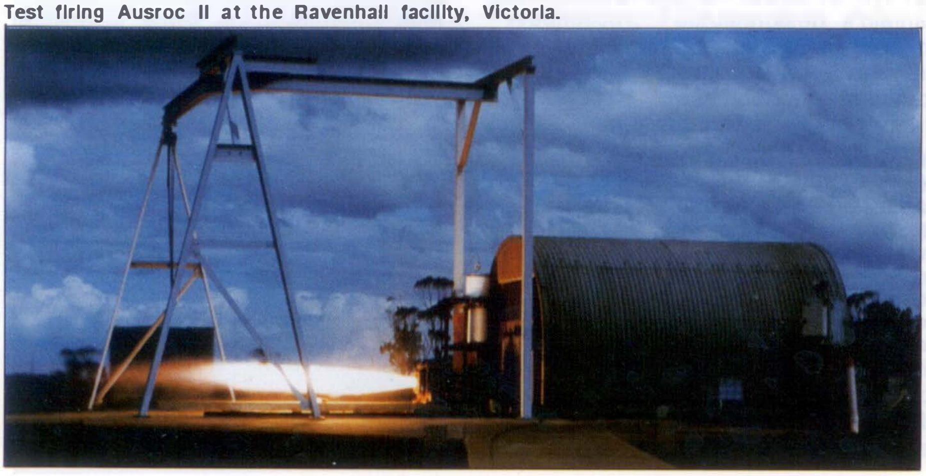
The rocket will be built from carbon composite lay-up and a high strength alloy, Aluminium 7075. If all goes to plan, this will be one of the most advanced and unique rocket structures ever developed. Construction of the "Ausroc III" will begin in earnest in 1994. There is no firm launch date, but launch will occur soon after the rocket's completion. If the rocket is successful, it is possible that it could be marketed to university an industrial researchers, but this is not currently envisioned.

Ausroc IV

If the Ausroc III programme is a success, the group will begin construction of a far more ambitious project, Ausroc IV. This would be a three stage vehicle with orbital capacity. The vehicle would use four Ausroc III rockets as its first stage, mated to a fifth Ausroc III, which would be ignited at high altitude to form the second stage. The third stage would consist of a spin stabilised solid rocket motor. This ambitious amateur vehicle would place a forty kilogramme satellite into a 300 km polar orbit.

The ASRI is currently working on an infra-red remote sensing satellite which would allow radio operators around the globe to request images to be taken and sent to them directly via radio. Currently the Institute envisions the satellite being launched on an Ariane rocket or possibly on an experimental rocket to minimise costs. ■

Test firing Ausroc II at the Ravenhall facility, Victoria.



Australia in Space

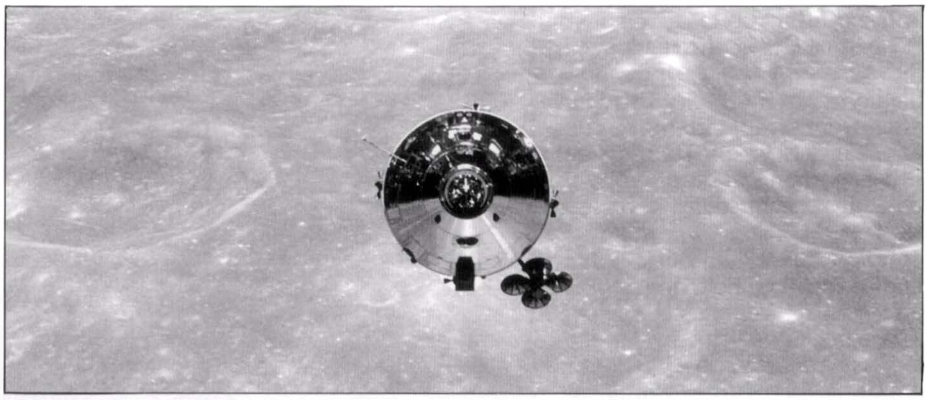
Australia has an interesting history in the area of rocketry and space development. In the 1950s the Woomera rocket range was an internationally renowned testing ground for USA and UK rockets. Australia was the third nation in the world to launch an indigenously built satellite from its own territory. Unfortunately for Australia, its rocketry history ended when the USA and the UK cancelled their operations at Woomera.

In the mid 1980s the Australian Space Office (ASO) was formed with minimal funding compared to other nations, e.g. the total funding for the ASO in 1990 was just US$ 4 m, or 0.001% of the GNP, compared with US$ 140 m in Brazil and US$ 194 m in Canada.

Due to these severe restrictions, Australian interests have been forced to devise their own rocketry proposals and have shown admirable ingenuity. These proposals range from amateur sounding rockets and micro-satellites to a commercial spaceport using Russian rockets, to developing a scramjet, and building a small commercial rocket for launching "Lightsats" from the Woomera rocket range in South Australia.

A Piece of Space Flight History

Finding myself in London recently, I paid a visit to the Science Museum and the Apollo 10 Command Module, Charlie Brown, or CM 106 to give it its official title.



Apollo 10 in lunar orbit, 175 miles East of Mare Smythii shortly after CSM/LM separation. NASA

Apollo 10 was the second manned flight to the Moon. On board were John Young, Gene Cernan and Tom Stafford, all three having been in space during the Gemini Mission. Apollo 10's task was to try rendezvous techniques in lunar orbit (Apollo 9 having done this in Earth orbit) with the LM going down to an altitude of just 50,000 feet above the lunar surface. This rehearsal was vital before attempting a landing.

The Apollo 10 mission was launched on 18 May 1969 from pad 39B, splashing down one week later on the 26th after a successful flight. With a successful testing of lunar orbit rendezvous techniques under its belt, NASA gave the go ahead for the Apollo 11 landing, now a part of history.

View of the Drogue Parachute Mortars (the two pan-like objects). Note also the negative pitch engines, the bar is to protect them. The steel cable is for lifting the CM onto an aircraft carrier. I.R.BROADBENT

Hoping to put some flesh on the bones of my research into Apollo, I made my way to South Kensington and the Science Museum. Some say - and many cynically agree - that all that Apollo produced of any significance was a non-stick frying pan and museum exhibits, and that huge amounts of financial and material resources were thrown at Apollo, seemingly without any real return.

Thankfully there are a great many who know this to be a short-sighted view of the worst possible kind. Flown items in the world's museums, such as the Apollo 10 CM, have their place in enlightening the public by giving them hands-on experience of a genuine spacecraft.

BY IAN R. BROADBENT
South Yorkshire, UK

Reentry Heating

Seeing the CM for the first time, I was surprised not to find more obvious charring around the cone. Only around the manoeuvring engines does charring stand out in any way where it was due to the intense heat created during their firing.

Of course, on the base, a lot of charring is visible, having taken the brunt of 2750°C from atmospheric heating. However, because of the way that the CM is displayed, with its base sitting on a plinth, the whole of it cannot be seen, though it is sufficient to show how the ablation process eroded the heat shield as it removed the unwanted heat.

The heat shield had been tested at lunar return velocities during the first flight of Saturn V in November 1967 when the service module engine was used to achieve re-entry velocity and slam Apollo 4 back into the atmosphere in order to prove the heat shield's design.

During flight, the Command Module is covered in a Silver Mylar thermal film making the CM highly reflective to light and heat. This can be seen very well in the photograph of the Apollo 10 CSM in lunar orbit. After re-entry at lunar return velocities, the mylar layer is almost burnt away, hanging in scorched layers.

On the other hand, Earth orbital CMs such as those of Apollo 7 and 9, Apollo/Soyuz and those used for ferrying crews to and from Skylab have a lot of this distinctive Silver Mylar film intact. Any remains of this layer are removed during post flight evaluation and Engineering checks. This does detract a little from a CM on display as from its appearance a lot could be gleaned by visitors of the intensity of the temperatures during reentry. On display, the colour is a distinctive dark brown, which is the heat shield's actual appearance, being a phenolic epoxy resin bonded to glass fibre.

As would be expected, the thickest layer is found on the base, where it is two inches thick, with a decrease to the apex, where the forward heat shield is half an inch thick. This forward heat shield surrounds the Earth landing system, containing drogue and main parachutes and buoyancy bags for uprighting the CM in the event of it being inverted in the water, plus various other pieces of equipment to assist in recovery.

Simulator Training

Inside the CM, its battleship grey creates a very clinical and functional feel, along with the sheer number of controls for operating Apollo Com-

Immediately below the window of the Apollo Command Module is a steam vent. To the right are roll engines. Below on the left is the urine dump and to the right a waste water outlet. I.R. BROADBENT

mand and Service Modules.

Apollo astronauts trained for hundreds of hours in the CM simulator which is an unwieldy looking device. It is described by the astronauts as the "train wreck" due to its system of projectors and mirrors to simulate, among other things, the passing lunar surface and other vehicles.

To simulate an entire mission from lift off to splashdown, the LM and CM simulators were linked by computer with simulated constellations for navigational star sightings and rendezvousing vehicles which varied in size with distance. In this way astronauts could navigate and see the effects of controls and course corrections on instrument readings, trajectories and orbits.

Simulated emergencies were also produced, the noise of boosters and stage separation being provided to create a real mission as far as possible. Many astronauts treated going to the Moon as just a very real simulator run, proving how realistic these simulations were in recreating an actual mission.

A view inside the Apollo 10 Command Module which is on display at the London Science Museum. At the dummy astronaut's feet is the lower equipment bay. Below the artificial horizon is the DSKY (display keyboard) for talking to the computer.

I.R. BROADBENT

Living in Space

How astronauts managed to live in the confined space of this spacecraft, is difficult to imagine for anyone here on Earth in a 1G environment. Interior film footage from a flight would have been invaluable in conveying to a visitor - puzzling over this - how radically altered a spacecraft becomes in zero G, allowing the astronaut an amazing agility and ability to occupy virtually every cubic inch. The agility shown by Apollo astronauts is astounding, moving with amazing ease in and out of extremely tight and narrow spaces and demonstrating superbly how adaptable human beings are to zero G. This agility was acquired after only a day or so of moving carefully within the CMs confines. Some of the astronauts at first had a certain light headedness, others just the opposite, while many felt any type of sudden movement, especially of the head, could bring on nausea and vomiting. Astronauts adapted inside the CM in their own individual ways. Jim Irwin (Lunar module pilot of Apollo 15) was very restrained and cautious soon after translunar injection when the crew had unstrapped themselves from their couches and had begun moving around. At the same time Al Worden was rapidly moving around working in the lower equipment bay.

CM Design Features

Apollo's CM possesses a superb high-quality engineering feel, not unlike a Rolls Royce, every part being beautifully made and assembled and giving some idea of the reliability needed.

The CMs dimensions are a diameter of 13 ft and a height of 11 ft with a weight of 5 tons. Its interior encloses 365 cu ft of space, 145 of which are occupied by equipment. Despite its solid cast look and feel, its construction is a brazed stainless steel honeycomb between two alloy face sheets, in total one half inch thick, with a strength equal to half inch thick steel plate, but with only a fraction of the weight. This also served as a meteor shield. Meteors penetrating the outer skin would be pulverised into powder by the impact. As this powder travelled between the two skins it would scatter and spread over a larger area of the inner skin. If the mass did penetrate the inner skin it would be pulverised and scattered before hitting the inner layers, consisting of two inches of insulation and the main pressure cabin, a one inch sandwich of aluminium plates and honeycomb.

Looking at the CM, it is daunting to think that every nut bolt, pipe and wire requires masses of paperwork to record every aspect of its size, shape, composition, where it was made and which batch of raw material was used. This gives a very vivid picture of the complexity of Apollo management with the million or so parts for the CM alone.

I was disappointed in the way that the Science Museum displayed what is by far its No. 1 space flight exhibit with a lack of photographs, literature and on-the-spot video from in-flight film clips to show exactly what role this piece of hardware played. To illustrate this inadequacy, there was somebody close by who was telling his friend how this spacecraft had landed and taken off from the lunar surface. ■

Pupils at the Royal Grammar School operating the receiving equipment in the school's ground station.

Satellite Imaging and Remote Sensing
at The Royal Grammar School

BY FRANK BELL
The Royal Grammar School
Guildford, Surrey

Getting Set Up

Our school has been involved in receiving satellite signals for about 12 years. It all started with the reception of the University of Surrey's experimental satellites UoSAT 1 and UoSAT 2. With a very modest outlay of £150 for a radio receiver, antenna and cables we found that we could receive live data from space. The thrill that this generated within the school had many spinoffs. Over a period of a few months we became experienced at tracking low Earth orbiting satellites and using the receiving equipment.

The science and engineering data we received was processed and analysed by our pupils. Pupils wrote decoding software and assembled the hardware interface which improved the signal quality to the computer.

Meteosat primary data image. It is a high resolution visible image showing the Eastern Mediterranean and Red Sea. Although Meteosat is primarily a meteorological satellite many surface features of the Earth can be distinguished.

Having experienced a sharp learning curve on the experimental satellites we quickly realised that signals from meteorological imaging satellites were also available to amateur and educational users. The temptation was too much; we had to try.

Additional equipment was purchased under the watchful eye of the bursar. In 1983 this meant signals into a BBC computer. Nowadays with SVGA graphics and multi megabytes of memory, it seems incredible to think we managed anything on a BBC computer but, although rather low resolution was achieved, the experience provided an invaluable foundation for handling the radio signals and satellite orbital predictions.

High quality imaging started with the purchase of a dedicated frame store. This was only able to handle one image at a time but the resolving power of the system approached that of the data contained on the incoming signal. An order of magnitude increase in quality was achieved over the BBC system.

The location of antennas is always difficult. It often becomes a compromise between accessibility and height on the building. However, antenna location should never be seen as a reason not to become involved. Often the simplest system will generate an astonishing quality of signal. Two years ago a major relocation of our school's ground station was undertaken. We moved from the lower ground level to the top of the building and we were never without some sort of satellite reception during the transition.

Polar Orbiting Satellites

Signals from the USA and Russian polar orbiting meteorological satellites have proved quite easy to receive and process. A fixed antenna in the form of a crossed dipole will receive satellite signals almost from horizon to horizon.

The American NOAA and Russian Meteor satellites conveniently both use the same APT signal format on the 136-138 MHz band. Hence both satellite types can be received on the same equipment. Orbital predictions are dealt with by the school's computers and the Keplerian elements for all the satellites are regularly updated from the data sets available via information from one of a number of bulletin boards in this country.

The NOAA satellites orbit at a height of about 700 miles and the best passes over the UK generate images ranging from Cyprus to Greenland and the Canary Islands to Spitzbergen. All are regularly received at the RGS Guild-

ford.

NOAA signals give parallel coverage of visible and infrared images. The IR ones give us the extended facility of temperature analysis of surface features.

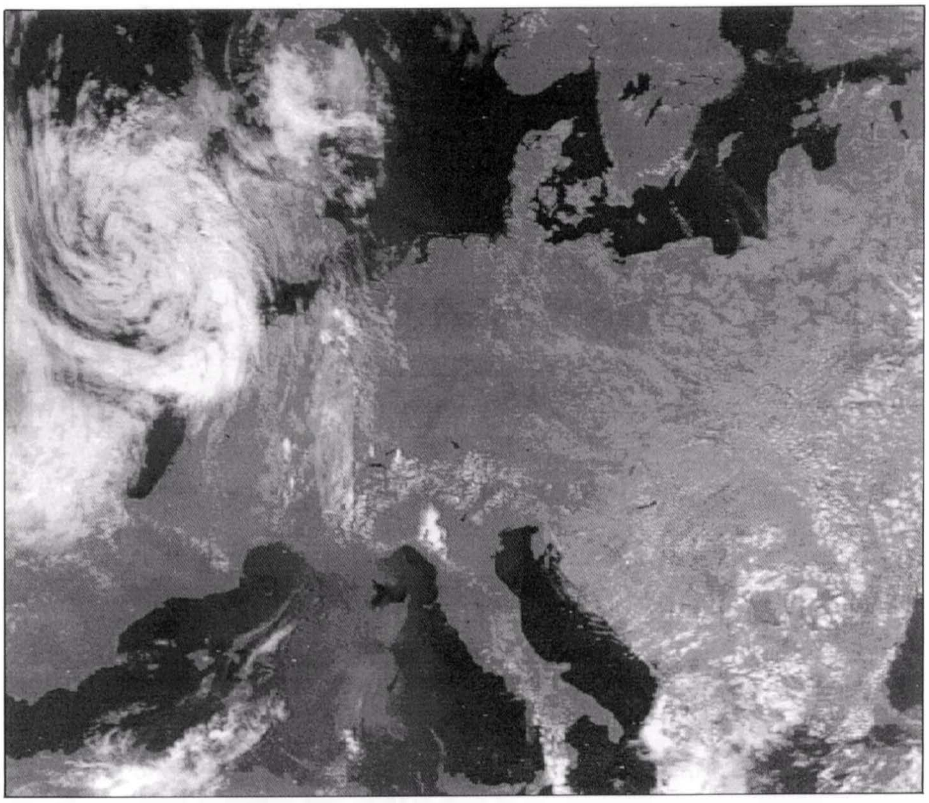
The Russian Meteor series also send visible and IR images but there are spectral differences between the satellites. NOAA satellites discriminate well between land and sea boundaries, whereas the Meteors are better at resolving between sea, ice and cloud.

Meteosat

We have never regretted our decision to invest in a dish antenna and a down-converter to change the 1.6 GHz meteosat radio signal to 137.50 MHz so that it is compatible with our other radio receivers. We also made the major decision to invest in a PC to display and process all our meteorological satellite images.

Meteosat sends images in two formats. The secondary data is in the APT format thus allowing us to process polar orbiting satellites and Meteosat images on the one system. The primary data which is digitally encoded rather than the analogue signals of APT required a larger dish and a new receiver. The regular reception of these high resolution pictures is the jewel of our meteorological activities.

There is no doubt that our activities have generated much interest with our pupils. Our first and second year science course uses our own satellite images. The purpose is to identify patterns of airflow and weather over the world and the relationship with vegetation patterns. A project we have at the moment is a study of sub Saharan Africa and seasonal changes in vegetation. Our sixth form general studies course allows pupils to use the equipment for data reception and then subsequent image processing. Extra curricular groups such as Scouts, D of E and CCF Signals also become involved in various aspects of satellite communication and imaging.



This is a NOAA 11 picture of Europe. The image shown is from the visible channel and was recorded in the summer 1993.

The school's ground station is busy almost every break and lunch time with pupils down-loading data to follow weather patterns and to capture files to take home and process on their own computers. It is certainly gratifying to see so many youngsters being sufficiently interested in remote sensing that they will spend their own time at home enhancing and displaying images.

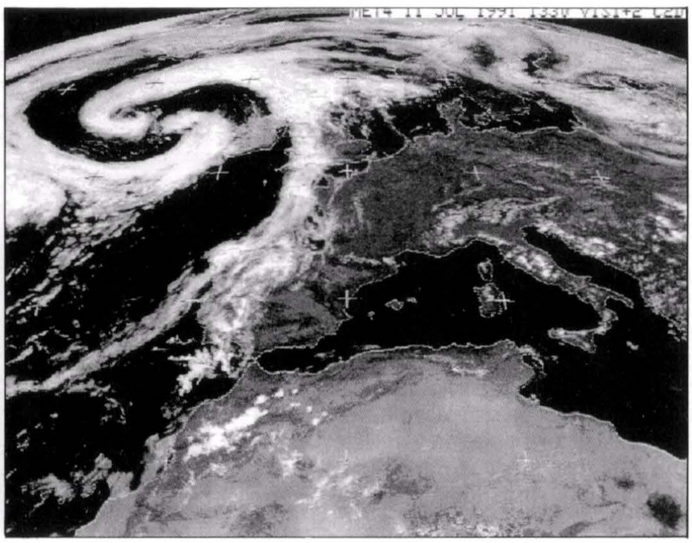
I know that many teachers are a little nervous about becoming involved in remote sensing but with a little understanding and confidence it is easy to receive live signals at school or even in your own home!

The illustrations show the type of images received at school. Meteosat primary and secondary data sets come in every few minutes, those from NOAA satellites once or twice a day and the Russian Meteor pictures as available.

To become involved in remote sensing is not difficult and the rewards for pupils are very worthwhile.

(All photographs supplied by the author).

Below Left: This is a visible image from one of the Russian Meteor satellites. The land on the lower right is Morocco and the Canary Islands can be seen upper right. The cloud swirls shown in the centre have resulted for vortex shedding downwind of the Canary Islands. Right: This is a Meteosat secondary data image of Europe.



Building rockets for "Neptune".

'The Orbital Mechanics'

Space Venture Projects for the National Curriculum

Space holds a fascination for most of us. ***The Orbital Mechanics*** **have devised a set of projects for schools which exploits this interest and brings it down to Earth! With our help, students can investigate scientific principles and technological developments, while giving free reign to their imagination and enthusiasm. The projects range from the design, construction and flying of Model Space Vehicles to Operating a Lunar Base; from modelling our Solar System to imagining life in an Alien Environment such as Mars or Venus.**

BY JOHN HODGES
Milton Keynes, UK
and
TREVOR SPROSTON
Letchworth, UK

Introduction

Our primary objective is to enhance the teaching of Science and Technology within the National Curriculum. However, our projects are cross-curricula, and cover aspects of Mathematics, Business Studies, Craft and Design, English and other languages, History, Geography and Art.

We aim our projects at middle and secondary schools and provide a complete package, including equipment, pre-visit notes and course management.

Some projects have been adapted for tertiary and adult education. They can be applied to personnel development training within a business environment. We also run versions of the projects for all ages over five, as leisure activities.

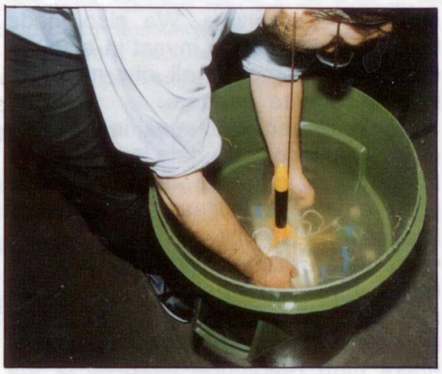
Rocketry Workshop

During the past few years, we have run a rocketry workshop as an activity at the Brunel School for Space Education. Because basic kit-building provided little room for the teaching of science, we adopted a problem-solving approach using rockets. So far have offered design projects; satellite stowing and deployment; business simulations, involving the construction and supply of an American space station; and performance analysis, i.e. critical examination of Estes data and the design of experiments to test their validity. In addition, at the Summer 1993 Brunel Space School, we decided to use rockets in the problem-solving context of attempting an underwater launch, hence project 'Neptune'.

Neptune

As a project it is quite neat. The students were required to produce a self-contained launch platform and ignition system, which entailed no physical contact with themselves, i.e. no wires leading from the barrel. There had to be a safety switch to prevent premature ignition and a delay between placing the assembly in the water and final ignition. The students thus had a variety of obstacles to overcome:

(a) Waterproofing the rocket, motor and electrical connections in such a way as not to short out the ignition sequence nor impede the recovery system.
(b) Designing a platform that would sink slowly to the bottom of the barrel and settle in a stable manner, without excess tilt;
(c) Designing a self-contained ignition and safety system to prevent premature ignition;
(d) Ensuring safety of the operators and observers.

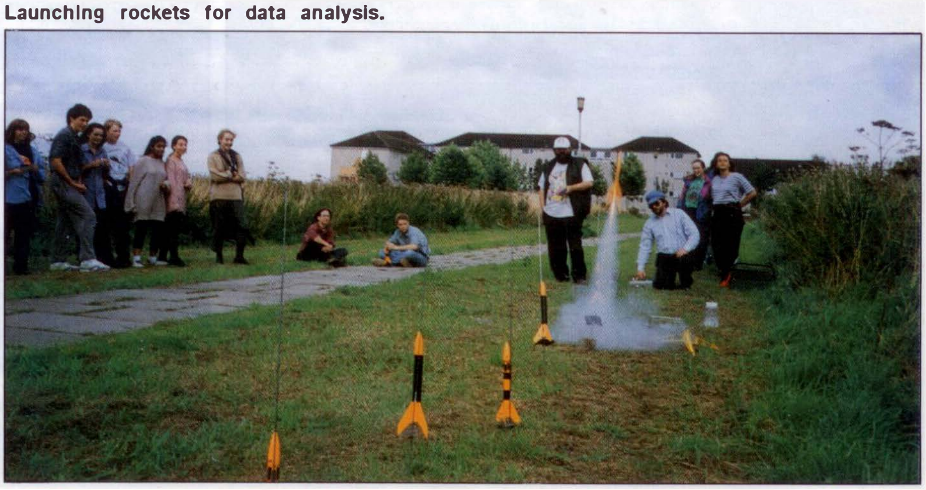


Testing a launch pad for "Neptune".

The students were provided with an Estes Alpha 3 as their rocket and were already familiar with it from the earlier experiments on performance. A "shop" was opened where they could obtain various specific components: push-to-make switches, mercury tilt switches, wire, clips, batteries etc. There was also a "Blue Peter" box containing potentially useful items like PET bottles, plastic containers et al. We found that the required construction period of four hours was just about adequate.

Obviously there was a considerable amount of exchange of ideas, with resultant similarity of final products. The main variation being in how the

Launching rockets for data analysis.



groups chose to protect their rocket - some going for waterproofing, some for isolation from the watery medium by means of an enclosed silo. In general the silo approach proved less than satisfactory, with only one example managing to penetrate the cling film seal on the open end of the silo.

It was obvious that the water would restrict the final altitude, nonetheless, we felt that safety demanded tethering of the rockets before launch. This proved largely unnecessary, as the trajectories did not deviate from the vertical by any excessive amount, and in any case, the rockets never achieved more than about 7 metres "altitude".

In all, there was about a 65% success rate to the project. All the participants enjoyed the activity, even if not all flights were successful. We have learned a great deal about how to set up sessions such as this, and look forward to further opportunities.

There follow details of our other projects which are compatible with the National Curriculum.

Living Planets

We use role play and problem-solving techniques to give the audience an idea of the scale of the Solar System, the prevailing conditions on each planet, and the mythology of each planet. They also have the problem of a remote-sensing simulation, involving the design of a lander that has to deposit an egg safely on a variety of surfaces. This was successfully trialled at the BAAS Family Festival at Keele last Summer.

Lift-Off

This is the model rocketry section. We offer a series of activities, including practical experiments in data-handling, problem-solving tasks such as underwater launches, rocket design, and aerospace business. For this latter item we simulate a space market that uses the resources of a substantial space station. The audience is divided into groups and is given a business to run. These businesses make use of the facilities of the station to produce various commodities. They must decide what to manufacture, how many modules to launch, what rocket they need to launch, and must recover their manufactured commodities to make a profit - market forces permitting of course.

A successful launch for "Neptune".

Top: View of moonscape for moonbase. Above: Monitoring progress on moonbase.

RABIT

'Role-play as Alien Bio-Intelligence and Technology' is a biology, mathematics and communication activity. Students learn about themselves as living organisms and how we as a species communicate - or fail to do so! It is carried out through the medium of a simulated encounter between alien species. It has generally produced some hilarious and thought-provoking situations as students struggle to resolve a crisis that can threaten interplanetary war. Fortunately, the fabric of the universe remains unrent.

Moonbase

A teleoperations simulation, being a much more advanced and involved version of 'Mining the Moon' which was an earlier project. Students remotely operate a Lunar Mining Operation from Earth. They have to fill quotas, maintain team discipline and organisation, and deal with several types of unexpected events - both natural and man-made.

Rover

This is basically a sample return scenario but with many aspects to the mission. The participants control the rover from a computer and have to decide on courses of action according to data received about the status of the vehicle itself and the sampling mission. This is our latest project and we intend to be running it at forthcoming demonstration events.

The Team

John Hodges is a Chartered Engineer with many years' experience in Academia and the Aerospace Industry. He now operates a design, consultancy and engineering business in Milton Keynes.

Trevor Sproston is a teacher of craft and technology who has had a long-term interest in Space Education in general and Model Rocketry in particular. Trevor has written several guides on how to make the most of children's natural interest in space affairs in the classroom.

SATELLITE DIGEST-263

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Soyuz-TM 18	1994-001A	Jan 8.42	Tyuratam	Soyuz	7,150 ?	Jan 10.54	51.62	92.24	385	392	[1]
Gals 1	1994-002A	Jan 20.41	Tyuratam	Proton-4	2,500 ?	Feb 1.49	0.21	1,443.08	35,888	35,959	[2]
TURKAT 1	None	Jan 24.90	Kourou	Ariane 44LP	1,783	Failed to reach orbit					[3]
EUTELSAT-2 F5	None				1,880	Failed to reach orbit					[4]
Meteor-3 6	1994-003A	Jan 25.02	Plesetsk	Tsyklon	2,215 ?	Jan 25.23	82.56	109.36	1,186	1,208	[5]
TUBSAT B	1994-003B				50 ?	Jan 26.14	82.56	109.36	1,185	1,209	[6]
Clementine 1	1994-004A	Jan 25.69	WR	Titan-2G	230	Jan 26.23	67.00	90.06	255	300	[7]
Progress-M 21	1994-005A	Jan 28.09	Tyuratam	Soyuz	7,250 ?	Jan 30.02	51.67	90.96	309	334	[8]

NOTES

1. Three manned spacecraft, carrying V.M. Afanasyev (commander), Y.V. Usachyov (flight engineer) and V.V. Polyakov (physician). Docked at the rear longitudinal port of the Mir Complex, at the rear of Kvant 1, 1994 January 10.49. Afanasyev and Usachyov are scheduled to remain in orbit until July 1994, while Polyakov is scheduled to complete a flight lasting for about 14 months, a new duration record.
2. First flight of new generation communications satellite, to be located over 44 °E.
3. TURKSAT 1 was the first satellite launched to the Turkish Ministry of Post and Telecommunications, to undertake telecommunications, television and data transmissions: mass quoted above is at launch, the projected mass for the beginning of operations in geosynchronous orbit was 1,078 kg and the dry mass was 827 kg, to be located over 42 °E.
4. EUTELSAT-2 F5 was to be operated by EUTELSAT in France for European communications: mass quoted above was at launch, the projected mass at the beginning of operations in geosynchronous orbit was 1,123 kg and the dry mass was 921 kg, to be located over 36 °E. Ariane's third stage engine stopped operating 80 seconds after ignition because the liquid oxygen turbopump ceased operating.
5. Seventh Meteor-3 to be launched (the first was a failure, identified as Cosmos 1612). Meteorological satellite, carrying French Scarab Earth radiation balance instrument and German PRARE (Precise Range & Range Rate Experiment) for precise orbit determination.
6. TUBSAT B (Technical University of Berlin Satellite) is built by the Berlin University and originally planned for launch aboard a US shuttle mission (STS-55/Spacelab D2). Carries experiments with high precision star trackers and small reaction wheels which will allow a new attitude control concept to be tested.
7. Clementine 1 is the first US spacecraft launched towards lunar orbit for 21 years. The mass quoted above excluding propellant (approximately 220 kg). Satellite carries Star 37FM motor for trans-lunar injection. Trans-lunar injection took place 1994 February 3.27: spacecraft will spend about 12 days in an eccentric Earth orbit prior to being captured by lunar gravity about 1994 February 21, the planned periselene being 425 km. Spacecraft will spend nearly three months mapping the lunar surface before being launched from lunar orbit about 1994 May 3 towards an encounter with asteroid 1620 Geographos in late August 1994. Satellite carries a ultra-violet/visible camera, infra-red cameras, lidar and radiation detectors.
8. Unmanned cargo freighter, carrying supplies to the cosmonauts aboard the Mir Complex. Docked with the Mir Complex 1994 January 30.16: docking announcement suggested that the docking was at the Kvant 1 port, but Soyuz-TM 17 had vacated the front longitudinal port earlier in January.

ADDITIONS AND UPDATES

1973-100B DSCS-2 4 (OPS 9434) was deactivated 1993 December13.

1978-113A DSCS-2 11 (OPS 9441) was deactivated 1993 December 13.

1978-113B DSCS-2 12 (OPS 9442) was deactivated 1993 December 13.

1984-081A Elements sets showing the retirement of EUTELSAT-1 F2 have now been issued: the final Two-Line Orbital Element showing the satellite on-station over 0-1 °E was dated 1993 October 28 and the next set dated 1993 December 2 showed the satellite in its drift orbit. Add the following orbit: 1993 December 2.25, 2.92°, 1,457.61 minutes, 36,172 km, 36,241 km. Calculations suggest that the satellite was boosted off-station approximately 1993 Nov 9.

1988-109A The first set of Two-Line Orbital Elements for Skynet 4B since 1993 October 18 were issued on 1993 December 24 showing the satellite with its longitude stable and relocated over 346 °E.

1990-094A Gorizont 21 has been relocated close to 145 °E, the first FSU satellite to use this location.

1990-112A Raduga 26 has been drifting since it was boosted off-station in early October 1993 and it is deemed to have been retired.

1993-003B TDRS 6 was relocated over 313 °E approximately 1993 November 30.

1993-043A Soyuz-TM 17 undocked from the Mir Complex 1994 January 14.19 with cosmonauts V.V. Tsibylev and A.A. Serebrov on board. After a fly-by of the Mir complex (including a collision with the Kristall module), the descent module landed 1994 January 14.35 215 km west of Karaganda.

1993-056A Mass of UFO 2 (USA 96) in its transfer orbit was 2,840 kg and on attaining geosynchronous orbit it was 1,279 kg.

STS-62

Columbia's Two-Week Mission

Basic Scientific Research and Experimentation

The launch of mission STS-62 occurred on schedule on Friday morning, 4 March at the opening of the launch window. The countdown was trouble-free as was Columbia's ascent into orbit.

Launch had originally been scheduled for the previous day, but NASA delayed the mission because of expected high winds at the launch site. The decision was taken early on the Wednesday afternoon with the launch re-scheduled for the Friday, when better weather was predicted.

By cancelling before fuelling operations had started on the Wednesday, NASA was able to save some $650,000, which is the estimated cost of cancelling a shuttle launch once the fuel tank has been filled.

Columbia carried two primary payloads; five experiments making up the first of these, the United States Microgravity Payload (USMP), and six more comprising a payload called OAST, an acronym for NASA's Office of Aeronautics and Space Technology.

USMP was devoted primarily to materials-science research with experiments on the growing of ultra-pure semiconductor crystals and other experiments to study how molten materials solidify. The OAST experiments were on technology developments for space use such as new solar array systems.

Mounted in Columbia's cargo was the Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument, which serves, among other things, to calibrate ozone-monitoring sensors on other satellites and thereby improve their performance.

Operation of the USMP, OAST and ozone experiments was primarily from the ground, allowing the astronauts to spend most of their time with in-cabin medical, biological and technology development experiments appropriate to space station construction and utilisation. One of the latter experiments involved setting up a miniature space station truss in the crew cabin for a series of engineering tests.

STS-62 crew at the base of the slide wire escape system for Pad 39B on the day of the Terminal Countdown Demonstration Test, 16 February 1994. Columbia surrounded by the service structure is in the background. From the left: Charles D. (Sam) Gemar, John H. Caspar (Mission Commander), Pierre J. Thuot, Andrew M. Allen (Pilot) and Marsha S. Ivins.

PETER GUALTIERI, WEST KENTUCKY NEWS

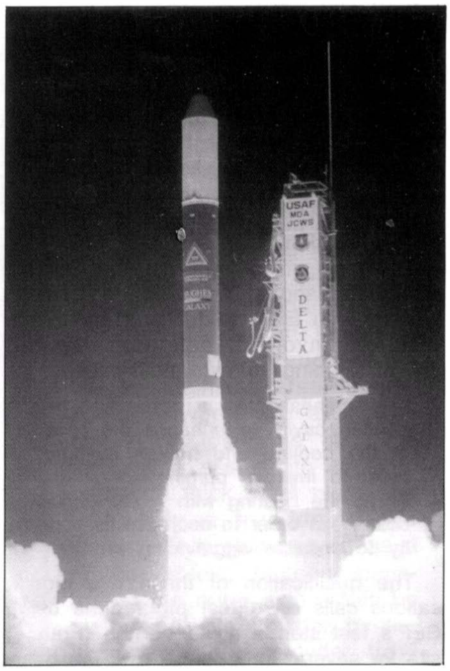
Launch Abort Delays Lift-Off

The launch from Cape Canaveral of the Galaxy I-R communications satellite for Hughes Communications, Inc was aborted on 9 February when the main engine on the McDonnell Douglas Delta II rocket failed to ignite. But all went well for the rescheduled launch on 19 February.

Scheduled for launch on 9 February with a window that opened at 6:20 pm EST (and closed at 7:42 pm), the countdown had to be re-timed for a 6:55 pm lift-off due to trouble with computer and other ground equipment. As the final seconds ticked by, launch commentator Anne McCauley's words aptly portrayed the situation, "...Three, two, one, zero. We have an abort. We have an abort". At the last second the main engine failed to ignite.

With the success of the re-launch attempt on 19 February, Delta rockets maintain their high reliability rate amounting to 98.9% success over the past 16 years and 91 launches.

The Galaxy satellite will be used by HBO, Cinemax, ESPN and other cable networks. It is to replace a Galaxy launched in 1983 which was to have been replaced by a satellite launched in 1992, but that replacement was destroyed when the Atlas rocket carrying it blew up.



Galaxy I-R is launched on a Delta II vehicle on 19 February 1994.

PETER GUALTIERI, WEST KENTUCKY NEWS

Electro

After ten years of delayed promises, the Russian Space Agency is ready to launch its first geosynchronous meteorological satellite, GOMS-1, now renamed Electro-1. With a mass of 2.3 tons, Electro is designed for a lifetime of 3 years. It will be launched in July or August by a Proton vehicle. Russia is planning to launch up to three Electro spacecraft during this decade.

THEO PIRARD

DC-X Programme to Continue

McDonnell Douglas has been notified that NASA is to provide funds for continuation of the Delta Clipper-Experimental (DC-X) programme. NASA and DOD are now studying options and laying out a plan to complete the original flight envelope testing of the experimental vertical-take off and vertical-landing launch vehicle.

Ariane Inquiry Report

On 18 February the Inquiry Board set up following the loss of Flight 63 reported that the shutdown of the third stage engine was the result of a generally insufficient cooling of the liquid oxygen immersed bearing, combined with aggravating factors that resulted in an overload of this bearing.

Following an analysis of the Board's recommendations, Arianespace, in conjunction with ESA, CNES and the manufacturers involved, defined corrective actions leading to two modifications:

- The installation of a purge line in the bearing cavity to enhance the reliability of the cooling and helium flushing, in order to improve purging;
- Fitting the bearing with a self-lubricating coating, in order to decrease its sensitivity to possible aggravating factors.

The qualification of these two modifications calls on a test programme using SEP's test stands at its Vernon (France) site for several turbopumps and the bearing test bench at the University of Liège (Belgium) to test a number of bearings.

Resumption of flights is targeted for the end of May, the date to be confirmed following the qualification process.

Brazil's SCD1 Completes One Year in Orbit

The Satélite de Coleta de Dados 1 (SCD1), the first Brazilian made satellite, is a data relay satellite and for the last year has been receiving daily data from its data collection platforms (DCPs) pilot network. The present number of DCPs relaying data to the SCD1 will increase considerably this year with the installation of around 250 new DCPs, which will be used mainly in the monitoring of the Brazilian hydrographic basins and in the control of floods. FABIOLA DE OLIVEIRA

Brazil Creates New Space Agency

On 10 February President Itamar Franco signed a law creating the Brazilian Space Agency, thereby combining the old Brazilian Committee on Space Activities and other space-related offices. The agency will help Brazil to coordinate development of its own rockets and satellites and to participate in the flow of transfers of goods and services needed for its economic and technological development.

ESA Go-Ahead for Manned Flights

On 15 February ESA's member states approved a $227 million Manned Space Transportation Programme and the building of a $299 million Columbus space station module.

The programme will include a crew transportation vehicle (CTV) which is a capsule-like device, crewed by four people, for servicing future space stations. ESA said the decision to go through with its programmes confirmed Europe's resolve to participate with all other partners, specifically the United States, Russia, Japan and Canada, in developing an international space station.

China's New Rocket

China successfully launched two satellites on 8 February with a newly developed rocket, the new Long March 3A, which can launch a 2.5 ton satellite compared with the 1.4 ton capability of the standard Long March 3. China is reportedly developing another rocket, the Long March 3B to put a 4.8 ton satellite into space as it enters the international launching business as a way of earning hard currency.

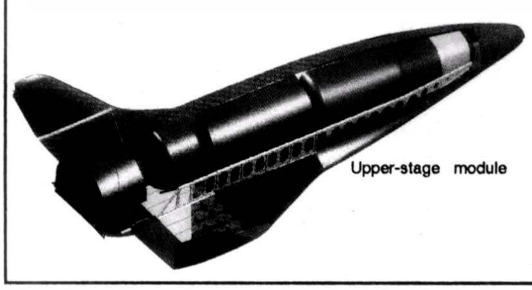
China's last launch on 8 October 1993 of a retrievable satellite (***Spaceflight***, November 1993, p.375) malfunctioned and did not return to Earth as planned. It is reported that the satellite, which was to perform microgravity experiments "went out of order" after circling the globe for about eight days.

Clementine Maps the Moon

The Clementine spacecraft which is now circling the Moon every five hours is producing detailed colour images of the lunar surface with up to 5,000 digital images per orbit. The spacecraft is to spend the next two months building the first-ever global digital map of the Moon and then fly off to intercept the near-Earth asteroid 1620 Geographos in August.

An official of the White House Office of Science and Technology Policy said that the plan to supply the images directly to Internet for computer access should enable the public to "reach in and touch the space programme directly". Among other things, he suggested, it will be possible for people to "fly around the Moon with their mouse".

Germany's Hypersonic Programme



System studies on the horizontal takeoff, winged and reuseable transporter "Sänger" are preparing for the development of a radically new space transportation system. Under the leadership of the Orbital Infrastructure Division, Dornier has developed a structural and fuel tank concept including wing and control surfaces for the upper stage of Sänger. DORNIER

India and Remote Sensing

India's Department of Space (DOS) has signed an agreement with the US-based EOSAT under which the latter will receive and market globally remote sensing data from Indian IRS satellites.

India is cashing in on its long-standing capabilities in the field of remote sensing. With about 75% of its population of over 900 million living off agriculture, crop protection through remote sensing is a vital effort. Annually, India loses about Rs 50 billion to various pests, Rs 15 billion to draught and Rs 7.7 billion to floods. A decrease in IR reflectance is one of the earliest symptoms of a reduction in the vigour in many plants. Changes in spectral reflectance help to identify not only the type of crop affected but also the pest or pathogen that causes the damage.

India's second-generation IRC-1C is due to be launched in 1994-95. EOSAT will receive and market IRS-1C data whether received at India's National Remote Sensing Agency ground station at Hyderabad or obtained direct from the IRS-1C tape recorder.

DOS feels there is likely to be much demand for IRS satellite data, particularly in view of the loss of Landsat 6 last October. IRS data is very similar to that from Landsat. HORMUZ P. MAMA

Swedish Industry Help Salyut KB

SAAB-Ericsson of Sweden has a $1 m contract from Russian KB Salyut to develop and furnish a special adapter as well as a new and unified separation system for the first commercial use of the Proton launch vehicle. The adaptor and the new separation system are being developed for first use with the Inmarsat-3 communications satellite. THEO PIRARD

Space Sailing

Cambridge Consultants Ltd (CCL) has been invited to help develop the European entry for the 'Lunar Cup', a race to reach the Moon using a sail powered only by the pressure of sunlight. CCL is now one of only four companies whose 'solar sail' designs are being considered by VSE (Voilier Solaire Européen), the Paris-based body co-ordinating Europe's entry in the race.

Space sailing employs the pressure exerted by sunlight which is very low, being around 8 grams weight per hectare, and the surface area of the sail has to be correspondingly large, up to 60,000 m^2. Designers predict that by using this small but constant force of sunlight, an acceleration of 1 mm per sec^2 will be achieved, and the sail and its cargo will reach the Moon in 300 - 350 days, depending on the skill of the Earth-bound navigators.

In their design, the CCL team used ingenious origami techniques to fold a sail the size of ten football pitches into a cylinder only 4 m wide by 4 m high.

CCL will have to wait to discover whether its design will be used in the Lunar Cup, which will take place in 1995.

NASA's first shuttle mission of 1994 lifts off on time from Launch Pad 39A at 7:10:01 am (EST) on 3 February after a flawless countdown. NASA

First 1994 Mission Heralds New Era of Space Cooperation

STS-60 was highlighted by the participation of a Russian crewmember aboard Space Shuttle Discovery. The mission also saw the first flight of the Wake Shield Facility to generate an 'ultra-high vacuum' environment and the second flight of the commercially developed SPACEHAB facility to provide an extra 1100 cu ft of working space for several experiments, which could lead to the development of space-based products and improved manufacturing processes on Earth.

Prelaunch Processing

Discovery returned from its previous mission, STS-51, on September 22, 1993 and was rolled into the Kennedy Space Center's Orbiter Processing Facility-Three (OPF-3). During the time it was there, the three main engines from STS-51 were removed and three refurbished engines were installed. These engines were numbers 2012, 2034 (which also flew on STS-51) and 2032. SPACEHAB-2 was then installed in the orbiter's payload bay.

On 4 January 1994, Discovery was transported to the Vehicle Assembly Building and, after being mated to the External Tank and Solid Rocket Boosters, was rolled out to Pad 39A on January 10.

The STS-60 crew leave the Operations and Checkout Building en route to Discovery at Launch Pad 39A on 3 February. NASA

The launch countdown began at 4:00 am Monday, January 31 with the clock at the T-43 hour point. A total of 32 hours and 10 minutes of built-in-holds brought the clock to T-0 at 7:10 am on February 3, 1994.

The countdown progressed with no major concerns. The cryogenic reactants for Discovery's fuel cells were loaded aboard the orbiter during the early hours of Tuesday February 1 and the pad's Rotating Service Structure was moved away from the Shuttle during the day. Later in the day, as orbiter systems checks continued, operations to stow time-critical experiments and equipment inside the SPACEHAB module began and were completed by the early hours of Wednesday, February 2.

After the Mission Management Team had assessed the weather the external tank was loaded with cryogenic hydrogen and oxygen propellants. The crew were awakened shortly after 2:00 am on the morning of the 3rd and departed for the launch pad shortly before 4:00 am. By 6:00 am the crew were in place in Discovery's cabin and the hatch was closed for flight.

The countdown continued without incident. At T-31 seconds the on-board computers took over control and between T-6.6 and T-4.6 seconds the three main engine fuel and oxidiser valves were opened and the three engines started reaching 100 percent power. The main engines then went to 104 percent power as liftoff came at T-0 at 7:10 am.

Discovery was launched on an approximately 57 degree inclination orbit. The Solid Rocket Boosters fired from T-0 to T+2:05 while the main engines fired until T+8:32 with Discovery in a 40 by 187 nautical mile orbit. At launch plus 42 minutes the orbiter's manoeuvring system engines fired to reach a 191 by 191 nautical mile orbit and mission STS-60 was underway.

About the Crew

Mission Commander was Charles F. Bolden, 47, Col., USMC. He was selected for astronaut training in May of 1980 and STS-60 was his fourth space flight. His first flight was as Pilot on STS-61C in January 1986, his second was as Pilot on STS-31 in April 1990 and his third was as Mission Commander of STS-45 in March 1992. Prior to STS-60, he had logged more than 481 hours of space flight.

Kenneth S. Reightler, Jr., 42, Capt., USN, was the Pilot of STS-60. He was selected by NASA in June 1988 and STS-60 was his second Shuttle mission. His first was STS-48 in September 1991. He had accumulated 128 hours of space flight prior to STS-60.

Mission Specialist-1 was Dr N. Jan Davis, PhD, 40, who was selected as an astronaut in 1987. STS-60 was her second flight as she had flown previously as Mission Specialist on STS-47 in September 1992. She has over 188 hours of space flight time.

Mission Specialist-2 was Dr Ronald M. Sega, PhD, 41, who was making his first space flight. He was selected by NASA in January 1990.

Dr Franklin R. Chang-Diaz, PhD, 43, was Mission Specialist-3 and Payload Commander for the mission. He was selected by NASA in 1980 and STS-60 was his fourth flight. He flew first on STS-61C in January 1986, then on STS-34 in October 1989 and next on STS-46 in August 1992. He had logged over 457 hours in space prior to STS-60.

Mission Specialist-4 was Sergei Konstantinovich Krikalev, 35, a Russian Space Agency cosmonaut. He joined NPO Energiya, the Russian organisation responsible for manned space flight activities in 1981. He was selected as a cosmonaut in 1985 and first flew aboard Soyuz TM-7 as a flight engineer. The mission was launched on November 26, 1988 and the crew stayed aboard the Mir space station until their return on April 27, 1989.

His next flight was as flight engineer aboard Soyuz TM-12, the ninth Mir mission, launched on May 19, 1991. Krikalev remained aboard Mir, performing seven spacewalks during his stay, until his return on March 25, 1992. In total, he has logged more than one year and three months in space.

Sergei Krikalev making final prepartions for entering Discovery's cabin prior to liftoff. NASA

Mission Operations Day-by-Day

Flight Day One

The STS-60 crew had much to do with activating SPACEHAB-2 experiments and other payloads in the payload bay, including several of those on the GAS Bridge Assembly.

With such a very busy timeline, operations began to run about two hours behind schedule and flight controllers elected to trim crew tasks in order to get the crew to bed on time at 6:10 pm. Operations with the SPACEHAB-2 Stirling Orbiter Refrigerator Freezer were postponed and Pilot Ken Reightler was removed from the list of first day medical subjects.

The first on-orbit television downlink at 3:18 pm (KSC-times) showed Sergei Krikalev at work in the SPACEHAB-2 module.

Flight Day Two

A short time after the crew awoke, Discovery flew directly over St Petersburg, Russia which is the home of Sergei Krikalev, who later photographed Moscow and other cities in his homeland using both US equipment and Russian equipment which had flown on the Mir space station.

With a slightly revised schedule of activities, the crew began a series of joint US-Russian metabolic investigations involving blood sampling.

SPACEHAB-2 operations continued and Ron Sega set up a bicycle exercise machine in Discovery's mid-deck. In preparation for the, then scheduled, deployment of the Wake Shield Facility on Flight Day Three; Ken Reightler checked out laser tracking gear as Krikalev, Sega and Jan Davis checked out the Remote Manipulator System (RMS) robot arm which was to be used for unberthing the Wake Shield Facility on the following day.

Flight Day Three

Crewmembers were awakened at 2:40 am with a rendition of the song "Rawhide" by members of the Johnson Space Center's STS-60 simulation and training team. The major activity of the day would be the unberthing and deployment of the Wake Shield Facility.

Ron Sega conducted a successful checkout of the satellite's communications systems, but reported seeing water droplets in the vicinity of the orbiter. After consultations with the Wake Shield's prime investigator Dr Alex Ignatiev and flight controllers, Mission Control advised that the droplets were most likely caused by a small "burp" of water from a tank dump nozzle and were not an obstacle to the release of the Wake shield. Accordingly, the Wake Shield satellite was unberthed at about 11:00 am.

The deployment of Wake Shield had to be postponed however due to several factors, including the inability to read the satellite's status lights and radio interference. After determining that the problem was not a systems failure, but a difficulty in reading the status lights, the crew and flight controllers prepared for another deployment attempt. Three deployment opportunities existed throughout the day.

On the next attempt, however, interference between the radio transmitter on the Wake Shield satellite and its payload bay carrier resulted in a decision to postpone the deployment activity until the following day.

Flight Day Four

The crew prepared for another attempt to deploy the Wake Shield satellite but a new problem prevented the deployment. The satellite's attitude control system was malfunctioning in that the horizon sensor on the ramside of the satellite was not communicating correctly with the attitude control system. The sensor uses a small rotating mirror which did appear to be functioning, and the decision was made to cancel the attempted deployment for the day and to analyse the problem in more detail.

With the present delay, a full mission could not be performed as the delayed retrieval would impact operations scheduled later in the mission. It was decided therefore to leave the Wake Shield outside the payload bay, held by the RMS arm, while the satellite operated the first portion of its epitaxy experiments. This approach would provide data on the experimental operations and still allow deployment for a shortened flight on Flight Day Five if the attitude control system failure could be fixed. Accordingly, the Wake

A special commemorative decal is fixed on the 100th Get Away Special (GAS) canister to fly on the Space Shuttle by Quality Engineer Maggie Carson of the Goddard Space Flight Center. NASA

Shield spent the "night" between Flight Day Four and Five growing a series of several Gallium Arsenide wafers while being held on the end of the RMS arm.

Flight Day Five

After a full analysis of the Wake Shield attitude control system problem, ground controllers elected not to attempt to deploy the satellite and it was decided to complete the series of wafer growing experiments with the Wake Shield held at the end of the RMS arm. This would allow the experiment to function and to be thoroughly tested in its operations. Accordingly, the Wake Shield was lifted above the port side of the payload bay where contamination by the orbiter would be minimised. Further flights of the Wake Shield were already on the Shuttle manifest and would provide opportunities for deployment after fixing the attitude control system.

Flight Day Six

The crew continued to use the Wake Shield Facility at the end of the RMS arm and moved the arm to various positions for an Air Force experiment aboard Wake Shield called the Charging Hazards and Wake Studies. This experiment measures the amount of electricity around the Wake Shield and Discovery.

Another Wake Shield experiment by the US Army's Construction Engineering Research Laboratory studied deposition of thin metal films in weightlessness to provide data on how reflective coatings may be applied while in orbit.

After the Wake Shield had completed the growth of five wafers while at the end of the RMS arm, a telemetry problem with it precluded further epitaxy growth operations.

Flight Day Seven

Discovery's astronauts were awakened at 3:10 am by Mission Control transmitting a variety of Russian folk songs in honour of Sergei Krikalev.

During the morning of the seventh day the Wake Shield Facility was returned to its carrier in Discovery's payload bay. The satellite was reberthed and the RMS arm was returned to its position and powered down for the remainder of the flight.

Following the end of activities with Wake Shield and the RMS, the crew turned their attention to the deployment of two secondary payloads.

At 9:54 am six Orbital Debris Calibration Spheres (ODERACS) ranging in size from 5 to 15.2 cm in diameter were ejected from a GAS canister on the GAS Bridge Assembly. ODERACS will help engineers to calibrate radar tracking and data analysis systems throughout the world and is geared toward small orbital debris-sized objects. Haystack orbital debris radars in Massachusetts acquired the spheres shortly after deployment and began a calibration programme that will continue for 120 to 200 days until the spheres reenter the Earth's atmosphere. ODERACS was originally scheduled for release during the STS-53 flight in December of 1992, however a faulty ODERACS battery prevented the ejection of the spheres on that mission.

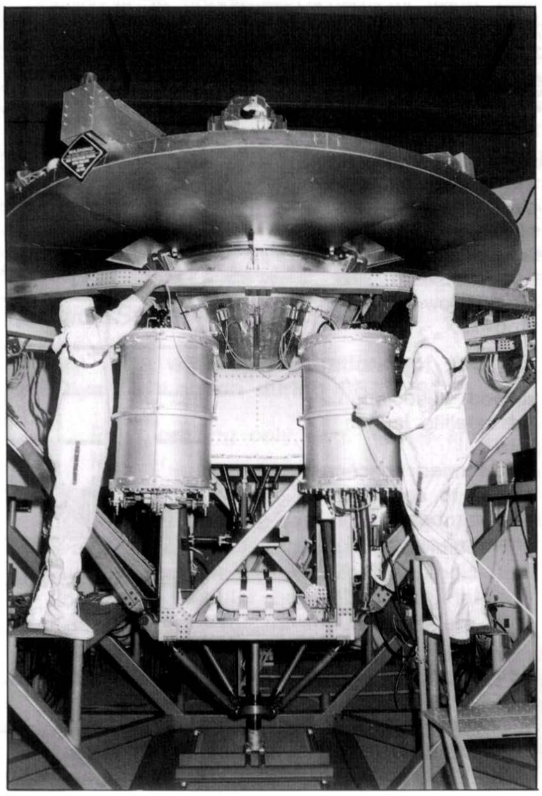
At 2:23 pm Discovery's crew deployed a 140 pound satellite called BREMSAT - also from a GAS canister on the GAS Bridge Assembly at the aft end of the payload bay. Built by the University of Bremen, the satellite will study micrometeorite movement, dust particles, acceleration forces, atomic forces and thermal conditions in space. Reentry of the 19 inch satellite will be approximately one year from deployment.

Flight Day Eight

On the final full day of the mission experiments in support of the joint US-Russian biomedical investigations were completed, as were the series of SPACEHAB-2 experiments. Later Jan Davis and Franklin Chang-Diaz shut down module experiments and stowed equipment in the SPACEHAB-2 module. Final deactivation was set for the following day.

Discovery's reaction control system hot-fire test and flight control checkout operations were conducted with no problems. These checks are made on the day prior to scheduled landings as

The Wake Shield Facility undergoing a vacuum leak check on September 3, 1993. NASA



a matter of course.

Mission Commander Charlie Bolden reported feeling a "shudder" coming from the back of the orbiter. It was the third, and largest, shudder reported on the flight. Previous crews have reported the same phenomenon, particulary on missions involving Spacelab or SPACEHAB modules. The shudders are believed to be the result of the orbiter and its payload adapting to changes in temperature due to the Sun warming differing portions of the payload bay, together with the cooling of the areas in the shade.

Flight Day Nine

There were two possible opportunities for a Kennedy Space Center landing on February 11. The first, which was the planned landing opportunity, was at 12:44 pm on orbit 130. The second opportunity involved a deorbit burn on orbit 130 with a landing at approximately 2:20 pm on orbit 131.

Low clouds and windy conditions forecast for the first landing opportunity resulted in the decision to wave-off from the 12:44 pm landing and to try for the second. The weather was acceptable for the second landing opportunity and Mission Control gave a "go for deorbit burn" with the actual burn coming shortly before the landing minus one hour mark.

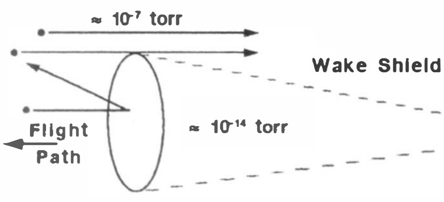
Discovery reentered successfully, performed a series of roll reversal manoeuvres and deactivated the reaction control thrusters in roll and pitch. About 14 minutes before landing the air data system probe deployed. Approximately 10 minutes prior to landing payload bay venting was initiated and final reaction control system deactivation in yaw was completed.

Discovery touched down at 2:19 pm on the afternoon of February 11 on the Kennedy Space Center's Shuttle Landing Facility. The mission had completed almost three and a half million miles of travel and 130 orbits of the Earth. Due to the later landing time, the crew delayed their return to Houston until the following day.

STS-60 Payloads

Wake Shield Facility (WSF)

This is a deployable payload designed to create a vacuum wake in low Earth orbit. The vacuum of space is 10^{-6} to 10^{-7} torr. At orbital velocities the WSF will produce a wake that will correspond to a 10^{-14} torr.



Ultra-Vacuum in space for Thin Film Growth. **NASA**

This extremely low vacuum allows the development of ultra-pure semiconductor materials. The WSF concept involves deployment using the orbiter's robot arm (RMS) and separation from the orbiter by use of its own cold-gas thruster. The WSF and the orbiter would then fly approximately 40 nautical miles apart for about 50 hours, during which time the WSF experiments are performed. The orbiter would later retrieve the WSF and reberth it in the payload bay.

The WSF free flyer is 12 feet in diameter and consists of the chassis, which structurally supports the Molecular Beam Epitaxy* and the Chemical Beam Epitaxy* experiments; the outer shield which serves to augment the wake created by the chassis; and the attachment bell which interfaces with the experiment and carrier to provide an enclosure for the epitaxy experiments.

SPACEHAB-2

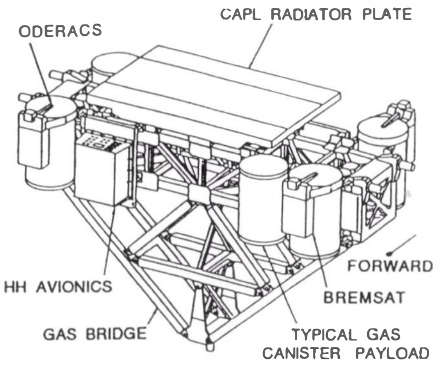
SPACEHAB is a pressurised module design connected to the orbiter middeck by a tunnel through which crew members move to it from the cabin area. It contained four material science, seven life science and one other experiment.

Material science experiments included; Three Dimensional Micro-gravity Accelerometer (3DMA); Equipment for Controlled Liquid Phase Sintering Experiment (ECLIPSE-HAB); Space Acceleration Measurement System (SAMS) and the Space Experiment Facility (SEF) furnace for growing cadmium telluride crystals.

Life sciences experiments aboard SPACEHAB-2 included Astroculture-3 (ASC-3) for hydroponic plant growth, Bioserve Pilot Lab (BPL) for biomedical and fluid studies, Commercial Generic Bioprocessing Apparatus (CGBA) used to store, mix, incubate and monitor biological samples, Organic Separation of Polymers (ORSEP) which demonstrates phase partitioning of immiscible polymers, Immunology-Mission One (IMMUNE-1) which studies the efficiency of the pharmaceutical PEG-IL2 in reducing the suppression of immunity in rodent, Penn State Biomodule (PSB) for biological and chemical microgravity studies, and Commercial Protein Crystal Growth (CPCG) for production of high-quality protein crystals for analysis.

Also flying on SPACEHAB-2's exterior was the Sample Return Experiment (SRE) which collected space dust by using silica aerogel mounted on the top of the module.

Get Away Special (GAS) Payloads



CAPL/GBA/ODERACS/BREMSAT payload configuration. **NASA**

The Capillary Pumped Loop Experiment (CAPL)

The Capillary Pumped Loop heat transfer experiment used ammonia to study a prototype of the thermal control system to be used on the Earth Observing System programme.

Orbital Debris Radar Calibration Spheres Project (ODERACS)

The ODERACS experiment deploys six small spheres (2-6 inch diameter) for calibration of ground based telescopes and radars used in orbital debris studies.

University of Bremen Satellite (BREMSAT)

BREMSAT is for studing the dynamics of atomic oxygen, dust particles and micrometeorites together with heat conductivity and momentum studies

Other Canister Experiments

A series of four GAS canister experiments studied the production of seamless hollow ball bearings in space, the vibration spectrum of the orbiter structure, and additional studies in Capillary Pumped Loop heat transfer. On the GBA was the 100th GAS canister to fly on a shuttle. This experiment studied the dynamics of boiling in microgravity. ■

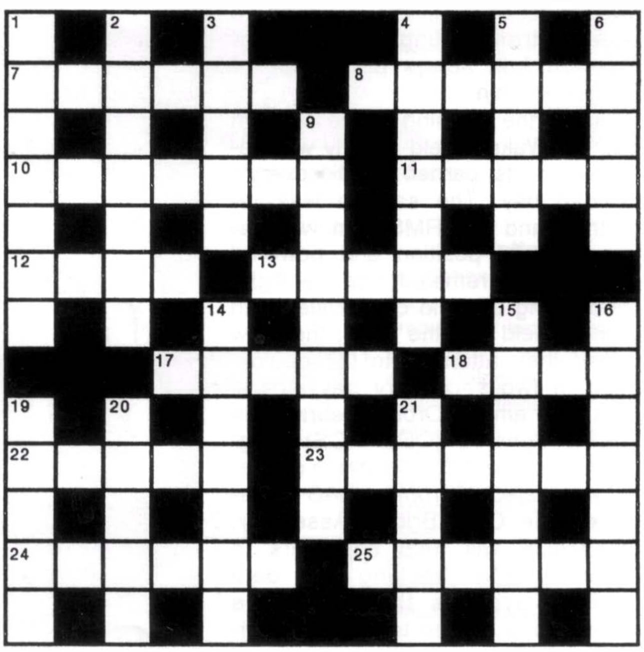
* Epitaxy is a technique of crystal growth through which a material is deposited on to a crystalline substrate in an atom-by-atom manner, preserving the overall crystallinity atomic-layer-by-atomic layer. Epitaxy experiments on WSF were Molecular Beam Epitaxy involving the direction of beams of atoms or molecules produced by thermal evaporation on to a heated substrate; and Chemical Beam Epitaxy which involves crystal growth by directing beams of gaseous molecules which dissociate on a heated substrate in ultra high vacuum.

Spaceflight Crossword

No. 8

ACROSS
7. Unfasten
8. Decay
10. Advanced Relay and Technology Mission in brief
11. Darkness
12. Let fall
13. Wear away
17. Intended
18. Shoo! to a sun-pointing spacecraft
22. Allotrope of oxygen
23. Task assignment for astronauts
24. ——— Nations
25. Paltry (ana.)

DOWN
1. Air Force Base by name
2. Global space ———
3. Rascal
4. Space Center by name
5. Feature of Saturn
6. Device to slow orbiter on landing
9. Star study
14. Cleaved
15. Organised association
16. Soviet satellite launch vehicle
19. Soviet manned spacecraft
20. Pertaining to sound-waves
21. Satellite for best performance award ?



Solution will appear in the May issue.

Solution to Crossword No.7.

ACROSS: 1. Rocket; 4. Motor; 8. Venue; 9. Envisat; 10. Troughs; 11. Maks; 12. Tip; 14. Idly; 15. Rims; 18. Air; 21. Lost; 23. Angular; 25. Grating; 26. Eying; 27. Theme; 28. Ascent.

DOWN: 1. Rivets; 2. Concord; 3. Energiya; 4. Move; 5. Tesla; 6. Retuse; 7. Least; 13. Progress; 16. Mellite; 17. Flight; 19. Range; 20. Bright; 22. Space; 24. Site.

NORMA

A Space Transportation System for the Next Century

BY LUC VAN DEN ABEELEN
Fellow BIS

The Russian organisations TsNIIMAsh and NPO Bulan are studying a new, man-rated, heavy-lift launcher. The booster will be partly reusable, as will its mobile launching pad. A scale model of the RS-9 NORMA space system was presented at the Moscow Aeroshow, last October. The concept of the launcher is fairly conventional, being a three-stage booster with engines running on kerosene and LOX and having a vertical launch. The launcher is however extremely powerful with a capacity to deliver 70 tons to an orbit at 200 km, *and* to return the same mass to Earth.

Artist's illustration of the NORMA space system. L. VAN DEN ABEELEN

Although NORMA cannot be called environmentally friendly because of the choice of fuels it uses, its physical launching characteristics are. There are no rocket stages or launcher elements other than the payload itself that reach orbit.

The NORMA designers have in mind some specific roles for the large rocket. The one they stressed most was the launching of radioactive waste materials in space and dumping it beyond the limits of the Solar System.

Other more conventional roles would be to orbit solar power stations, space factories, large space stations, elements of lunar bases etc.

The flexible launch operations add extra utility to the system. NORMA would be launched from a mobile platform, PSK-9, consisting of 6 modules which could be erected on any first or second class airport on the globe, preferably near the equator. Installation of the pad would take only seven days.

An interesting aspect of the design of the PSK-9 platform is that it also allows other boosters to be launched from it. Ariane 5, Titan 4, Zenit and Energiya-M were the types mentioned.

Both launcher elements and launch pad would be capable of re-use up to 500 times. Projected development costs amount to $13,044 million for the RN-9 booster and $750 million for the PSK-9 launch pad. TsNIIMAsh and NPO Bulan estimate the kilogramme-to-orbit price could get as low as $357 if 20 flight sets were to be constructed.

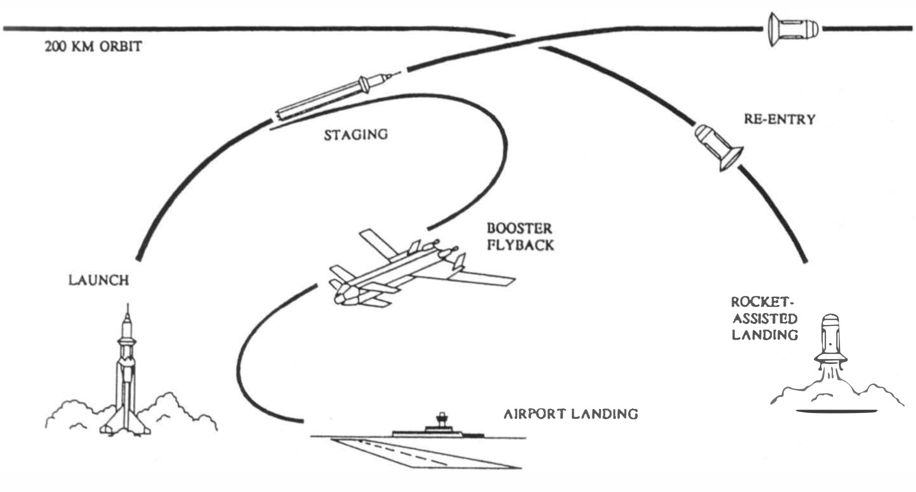
The RN-9 would stand some 80 m tall before launch; the crew, unspecified in number by the designers, sitting in the very top of the vehicle. Like the Soyuz launch vehicle, an emergency escape system would be available, pulling the crew module free from the spacecraft. During launch, the tube-like first stage would carry the rest of the vehicle inside it. After shutdown of the four main engines and staging, it would fold out two main wings at its base and four smaller ones at the front and fly back to the 'launch airport'. The controlled, unmanned landing would be assisted by four air-breathing engines.

The four-engine second stage would take the spacecraft into space, without reaching orbit itself. This allows the second stage to fall back to Earth and burn up in the atmosphere. The spacecraft's own engines would circularise the orbit at 200 km.

Return to Earth would be accomplished by firing the retro-rockets, followed by a descent through the dense layers of the atmosphere. Landing would be executed along the lines of the DC-X flights; six engines firing and touching down on legs. (The TsNIIMAsh representative at the Moscow Aeroshow was, however, unaware of the Delta Clipper effort).

Clearly, NORMA is not a system that can be realised in the near future. But because of its reusability, large payload capacity and flexibility in launch location, it may be a very attractive design for space operations after 2000.

NORMA flight profile.



The Next Step in Physics-Chemistry and Astronomy

A.H. Grundy, The Book Guild Ltd., Temple House, 25 High Street, Lewes, East Sussex, BN7 2LU, 1993, 239pp, £16.95.

Despite the apparent precise appearance of many ideas in modern physics, some of its basic theories are still subject to flaws and contradictions and/or simply do not explain some important facts. For example, we know what energy *does* but do we know what it *is*? Similarly, Quantum theory and relativity are both promoted as answering fundamental problems, but Newtonian physics, without relativity, still enabled us to get to Neptune!

In this book the author breaks new ground in trying to attack some of these questions, i.e. what energy really *is* and what atoms really are constructed from. He also presents new interpretations of Young's Light Theory and of the Michelson-Morley experiment. A good flavour of his thrust comes from his assertion that, though time and velocity are extremely useful, if not vital to humans, they do not actually exist.

Star-Hopping for Backyard Astronomers

A.M. MacRoberts, Sky Publishing Corporation, 49 Bay State Road, Cambridge, MA 02138-1200, USA, 1993, 160pp, $21.95.

This book develops the idea of jumping from one recognisable star to another in order to locate intriguing, but less conspicuous, celestial objects nearby, thus providing an organised way of exploring the heavens with a telescope.

Introductory chapters describe how to choose and use a telescope, how to understand star charts and celestial coordinates and how to observe faint objects. Twelve monthly charts are included which show the area of sky covered by each of the fourteen telescopic "star-hops" which, altogether, take in 160 galaxies, nebulae and star clusters of varying observational difficulty.

Race to the Moon: America's Duel with the Soviets

W.B. Breuer, Greenwood Publishing Group Inc., 88 Post Road West, PO Box 5007, Westport, CT 06881, USA, 1993, 232pp, $24.95.

This book presents an account, heavy with intrigue, espionage and controversy, about the race between the US and the USSR to be first to place a man on the Moon.

It begins with intelligence received by the British during WW2 that Germany was developing long-range rockets. Documents provided to the British showed that the Germans were some 25 years ahead both of the UK and US in rocket development, with the result that, even as fighting raged, a group of US Officers connived to steal 100 of the V2s located at an underground factory and ship them to White Sands, New Mexico, together with as many rocket scientists as could be found.

In the years that followed, von Braun and a high proportion of his Rocket Team were whisked to America and, in course of time, most became naturalised US citizens.

This story occupies about two thirds of the book. The remaining third is occupied by a readable and concise summary of the steps taken by the US to reverse the lead shown by the Soviets in orbiting Sputnik 1 in October 1957. This was an event which filled world headlines and threw into sharp relief the earlier American decision to develop the US Navy Vanguard, instead of adopting the concepts and hardware already produced by von Braun and his team for the US Army which later led to the launch of Explorer 1. Unfortunately, no similar account is given of behind the scenes activities on Soviet plans.

The Grand Tour: A Traveller's Guide to the Solar System

R. Miller and W.K. Hartmann, Workman Publishing, 708 Broadway, New York, NY 10003, USA, 1993, 208pp, $25.95 Hardback, $14.95 Paperback.

This revised edition of a book by two members of the Society which was first published in 1981, presents ten new chapters, 24 new photographs and 52 new or revised paintings based on the information revealed by space probes over the last decade. The Magellan Mission mapped the volcanic peaks of Venus, some even higher than Mount Everest, while Giotto provided a host of new data on Halley's Comet, including the first clear image of the comet's nucleus. A comprehensive exploration of four planets and their satellites was completed by the Voyager spacecraft while the Galileo probe photographed several asteroids, for the first time, at close range.

All this data has been encompassed in a book which then develops a visionary attitude to a range of possible landscapes of our planetary neighbours.

Optics in Astronomy

J.V. Wall, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1993, 288pp, £35.

Recent technological advances have brought about major changes to ground-based optical astronomy. This book features contributions from a range of experts to show the fundamental role that innovative optical design is now playing in modern astrophysics and cosmological research.

Information is presented on new and future telescopes, instruments, spectrographs and detector systems, all described in the context of specific areas of research towards which they are being targeted. To that extent, it not only gives the present state-of-the-art but also points towards the future of instrumentation design.

The Southern Sky Guide

D. Ellyard and W. Tirion, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1994, 82pp, £9.95.

This book provides a handy reference guide to the skies visible from the southern hemisphere. It features 24 charts showing constellations visible early and late in each month plus 20 sectional charts of the sky which give particular attention to constellations seen from the southern skies.

Accompanying text provides an introduction to the study of the night sky and describes the main features on the Moon's surface. It also gives advice on how to make the best use of binoculars and telescopes.

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These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

Happenings Around Supernova 1987A

Expanding Gas Sparks Bright Patches in Surrounding Ring-Shaped Nebulae

On 23 February 1994, it will be exactly seven years since the explosion of Supernova 1987A in the Large Magellanic Cloud was first observed at a distance of approximately 160,000 light-years. It was the first naked-eye supernova to be seen in almost 400 years.

After several years of relative quiescence, things are now beginning to happen in the immediate neighbourhood of SN 1987A. Recent observations with the 3.5 m New Technology Telescope (NTT) at the European Southern Observatory indicate that an interaction between the stellar material which was ejected during the explosion and the surrounding ring-shaped nebulae has started. This signals the beginning of a more active phase during which the supernova is likely to display a number of new and interesting phenomena, never before observed.

Seven Years in the Life of SN 1987A

After brightening to maximum light at magnitude ~3 a few months after the explosion, the long period of steady fading, which is typical for supernovae, set in by mid-1987. The matter ejected by the explosion took the form of an expanding fireball, which began to spread through the nearly empty space around the supernova with a velocity of almost 10,000 km/s. As it cooled, the temperature and therefore the total brightness decreased and the supernova became fainter and fainter. At the present moment, the magnitude of SN 1987A is about 18.5, that is almost 2 million times fainter than it was at maximum.

Various phenomena have been observed around SN 1987A during the past years. Already in early 1988, light echoes were seen as concentric, slowly expanding luminous circles; they represented reflections of the explosion light flash in interstellar clouds inside the Large Magellanic Cloud, lying directly between the supernova and ourselves.

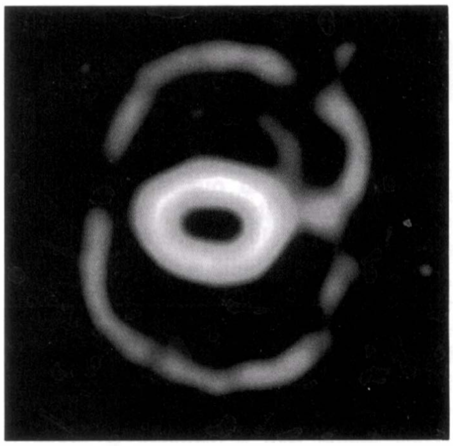
In 1989, high-resolution observations with the NTT showed an elliptical "ring-nebula", only two arcsec across, surrounding SN 1987A; it was interpreted as interactions between pre-existing circumstellar material and a shell of matter which was thrown off a few thousand years ago when a red giant star evolved into the blue star that eventually exploded. The best images of this nebula were first obtained by the Hubble Space Telescope in 1990.

During the past years, astronomers working at large telescopes in the southern hemisphere have conducted unsuccessful searches for a pulsar inside SN 1987A. Although most theories predict the emergence of a very compact object at the centre of a supernova, even very detailed investigations reaching very faint light levels have so far not been able to prove the existence of such an object in SN 1987A.

Recent Changes in the Ring

But the development of SN 1987A is not yet over. After the first seven years, it is now about to enter a new phase.

In a Circular of the International Astronomical Union, astronomers Li-Fan Wang (Beijing Observatory) and E. Joseph Wampler (European Southern Observatory) have just reported that changes are seen in the inner ring nebula around SN 1987A when the latest NTT observations are compared with those carried out over the past two years.



This computer-processed picture is an average of two 15-min exposures, obtained in the light of ionised nitrogen during the morning of December 20, 1993, at the European Southern Observatory. It shows the complex structure of the faint nebulae around SN 1987A. The inner ring was formed from interaction with matter ejected during an earlier phase by the star that later exploded as a supernova. Spectra and theoretical models suggest that the faint outer nebular loops trace the outer rim of a large bubble which was also formed by outflowing matter. ESO

The distribution of light along the ring has recently changed dramatically. It is now found to be gradually increasing in brightness at several locations.

This is most easily seen on images obtained in the light of ionised nitrogen which enhances the contrast between the SN 1987A ring nebulae and their surroundings.

Following computer sharpening of December 1993, CCD pictures to a resolution of 0.2 arcseconds - corresponding to the angle subtended by a coin of 1 cm diameter at a distance of 10 km - it is clear that the ring emission regions are now highly clumped.

Dramatic Changes Expected

It is most interesting that these new bright patches in the inner ring coincide roughly with the recently observed structure of radio emission received from SN 1987A. It is likely that these changes in the ring may herald the beginning of the predicted collision between the matter in the expanding fireball and the nebular material which was ejected from the star during the evolutionary phase that preceded the explosion. The supernova shell is "catching up" with the material that was ejected earlier.

This interpretation is also supported by the recent observation of weak X-ray emission from the supernova with the ROSAT satellite. It probably signified the beginning of heating of the gas inside the nebular ring due to high speed particle collisions.

These important observations have alerted astronomers to watch out for sudden, possibly quite dramatic changes in the ring. As a result, SN 1987A will now be monitored much more intensively. Never before has it been possible to observe such an event directly.

New European Astronomy Centre

Problem of High Data Storage Rates Tackled

Contracts of £0.5 M and £1.3 M have been awarded to data recording specialists Penny and Giles Data Systems of Wells, Somerset, to develop and supply a major electronic sub-system to be used at a new radio astronomy correlation facility in The Netherlands. The equipment will format and pre-process astronomical data received on high density digital magnetic tape from up to twenty radio telescopes around the world.

The technique of cross-correlating data recorded at widely separated radio telescope locations is known as very long base-line interferometry (VLBI) and is one of the most sensitive methods available to astronomers for probing the depths of the universe.

Most European VLBI observations are conducted by a consortium of radio astronomy institutes known as the European VLBI Network (EVN) which was formed in 1980 and now includes nine institutes and twelve telescopes in western Europe together with associate members in Poland, Russia, the Ukraine and China.

In order to capture the very high data rates involved (typically in the 500 Mbit/s to 1 Gigabit/s range) from observation sessions which often span many days, the VLBI community has adopted an extremely high capacity recording process in which groups of very narrow tracks are written in alternate directions along a 1-inch wide magnetic tape. One 15 inch reel of tape can hold up to 4000 Gigabits.

However, as the science of VLBI has evolved with time, so have the number of recording formats employed. The purpose of the new equipment, known as the Station Unit, will be to reconstruct many types of data into a single, standard format suitable for correlation without further manipulation.

First Optical Identification of an Extragalactic Pulsar

The Large Magellanic cloud (LMC) is a satellite galaxy to our Milky Way galaxy and one of the most studied objects in the sky. Besides several millions of stars it also contains a great number of clouds of gas and dust, some of which are the remains of gigantic supernova explosions in the past when heavy stars in the LMC became unstable and blew up.

One of these clouds (a nebula) has a circular shape with a diameter of about 6 arcseconds and is believed to be the remnants of a supernova which exploded some 760 ± 50 years ago. A group of American astronomers studied the data from the Einstein X-ray satellite observatory in 1984 and found that pulsed X-rays are emitted from the direction of this nebula. The pulsation frequency is unusually high and is explained by the presence of a pulsar, somewhere inside the nebula. The pulsar is an extremely compact neutron star weighing as much as the Sun but with a diameter of only 10-15 km and was created by enormous pressures during the supernova explosion. Its observed pulses indicate that it is spinning around its axis once every 0.05 seconds. The nebula in which it is embedded contains the rest of the material thrown out during the explosion.

The new object has received the designation PSR 0540-693 (the numbers indicate its approximate position in the sky). It has many similarities with the Crab pulsar and nebula and has been nicknamed the Crab Twin. Observations which led to the clear identification of the pulsar image were first taken in late January 1993.

Space Probe Diary

31 January 1994

Galileo

The spacecraft is 620 million km from the Sun and will go into orbit around Jupiter and relay data from a probe in its atmosphere on December 7, 1995. The spacecraft's condition is excellent, except that the high-gain antenna is still partly deployed and the mission team is planning to use the low-gain antenna for the Jupiter mission. Galileo was launched on October 18, 1989. It flew by Venus in 1990 and the Earth in 1990 and 1992 for gravity assists, and flew by the asteroid Gaspra in October 1991 and Ida in August 1993.

Magellan

The Spacecraft is in orbit around Venus between altitudes of 197 to 541 km and has been mapping the planet's gravitational field through precision tracking since this orbit was achieved by aerobraking in mid-1993. The spacecraft's condition is very good. Magellan was launched on May 4, 1989. It radar-mapped more than 98 percent of Venus's surface from September 1990 to September 1992.

Ulysses

The spacecraft is in a highly inclined solar orbit, now about 51 degrees south relative to the solar equator, and about 550 million km from the Sun. Ulysses will make solar polar passages (about 80 degrees south and north) in 1994 and 1995. Spacecraft condition and performance are excellent. Ulysses is gathering data on the heliosphere, which is the region of space dominated by the solar wind. The spacecraft was built by ESA and launched on October 6, 1990.

Voyager 1 and 2

The two Voyager spacecraft are continuing their interstellar mission, currently taking data on magnetic fields and charged particles as well as ultraviolet intensities. Voyager 1, launched on September 5, 1977, is currently 8.2 billion km from the Sun after flying by Jupiter and Saturn in 1979 and 1980. Voyager 2, launched on August 20, 1977, flew by Jupiter (1979), Saturn (1981), Uranus (1986) and Neptune (1989), and is now 6.3 billion km from the Sun.

'Apollo Quotes' Competition

With the approach of the 25th anniversary of the first manned landing on the Moon in July, the events of the Apollo program will be receiving increasing attention. This month's competition focusses on some of the well-known statements connected with the program, which have since become part of its history.

Prizes: The first five correct entries to be opened after the closing date of 5 May 1994 will receive a copy of the newly released video:

Arthur C. Clarke on Video

Apollo 11 astronaut Buzz Aldrin and "Sky at Night" TV Personality Patrick Moore lead a question and answer session with Arthur about his work - past , present and future. Further details may be found on the inside front cover

To Enter: Write out the following four quotations in which each consonant has been replaced by an asterisk:

I *e*ie*e **a* **i* *a*io* **ou** *o**i* i**e** *o a**ie*i** **e *oa*, *e*o*e **i* *e*a*e i* ou*, o* *a**i** a *a* o* **e *oo* a** *e*u**i** *i* *a*e** *o **e Ea***.
(John F. Kennedy, May 25, 1961).

....

....

*ou**o*, **a**ui**i** *a*e *e*e. **e Ea**e *a* *a**e*.

....

a*'* o*e **a **e* *o* *a*, o*e *ia** *ea* *o* *a**i**.

....

*ou**o*, *e'*e *o* a **o**e* !

....

Title/Name ....

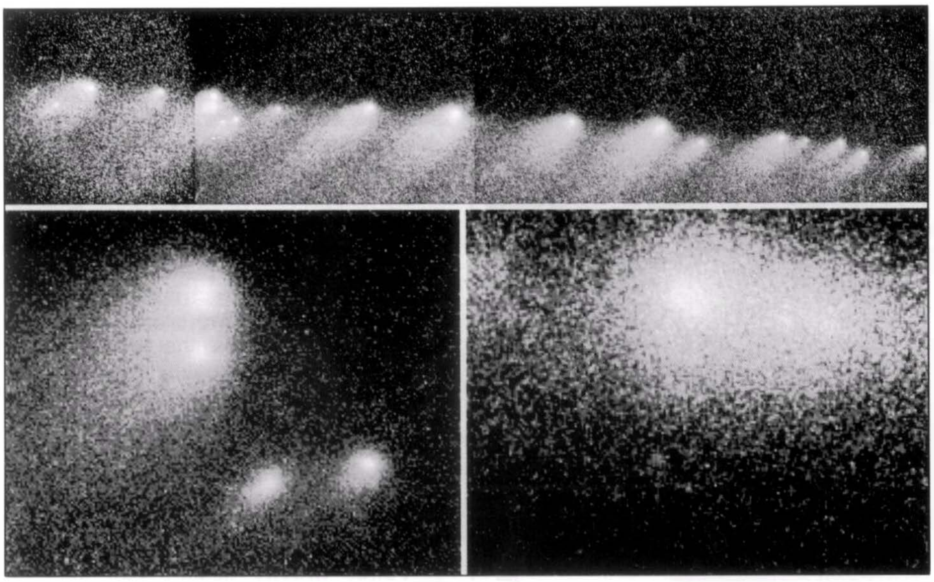
Address ....

....

....

Post to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England
To arrive by first delivery on 5 May 1994.

Tapes are VHS PAL format only and are not compatible with the US NTSC system.



Upper strip: A mosaic image of Comet P/Shoemaker-Levy 9 (1993e) consisting of two new Wide Field Camera images and one new Planetary Camera image. Twenty comet pieces are visible.

Lower right: An image taken with the Planetary Camera in July 1993 before Hubble was serviced.

Lower left: An image taken with the Planetary Camera in January 1994 after the Hubble servicing mission. The comet fragments can be seen much more clearly. Although it is difficult to discern by a comparison of these "before" and "after" images, detailed analysis shows that the separations and orientations of the four comet fragments have changed dramatically in the 6-month span between the two exposures.

DR H.A. WEAVER and T.E. SMITH STScI/NASA

Comet Heads for July 1994 Impact with Jupiter

Intensive Observational Campaign Planned

Observatories all over the world are preparing for a unique event: during six days in July 1994, at least 21 fragments of comet Shoemaker-Levy 9 will collide with Jupiter. This is the first time ever that it has been possible to predict such a collision. Although it is difficult to make accurate estimates, it is likely that there will be important, observable effects in the Jovian atmosphere. The Hubble Space Telescope is being allocated 23 hours of observing time and has recently viewed the comet with its refurbished optics. Galileo, Ulysses and other interplanetary spacecraft may also be called upon to make observations.

What is Known About the Comet?

Comet Shoemaker-Levy 9 is the ninth short-period comet discovered by Gene and Carolyn Shoemaker and David Levy. It was first seen on a photographic plate obtained on 18 March 1993 with the 18-inch Schmidt telescope at the Mount Palomar Observatory, California. It was close in the sky to Jupiter and orbital calculations soon showed that it moves in a very unusual orbit. While other comets revolve around the Sun, *this one moves in an elongated orbit around Jupiter*. It is obvious that it must have been "captured" rather recently by the gravitational field of the planet.

It was also found that Shoemaker-Levy 9 consists of several individual bodies which move like "pearls on a string" in a majestic procession. It was later determined that this is because the comet suffered a dramatic break-up due to the strong attraction of Jupiter at the time of an earlier close passage to this planet in July 1992.

High-resolution Hubble Space Telescope images have shown the existence of up to 21 individual fragments (termed "nuclei"), whose diameters probably range between a few kilometres and a few hundred meters. There is also much cometary dust visible around the nuclei. No outgassing has so far been observed from Shoemaker-Levy 9, but this is not unusual for a comet at this large distance from the Sun, about 750 million km.

Where and When Will the Collision Take Place?

From accurately determined positions of the individual nuclei, it can now be said with 99% certainty that all of them will indeed collide with Jupiter. The points of impact are in the Jovian southern hemisphere, at -44.3° $\pm$ 0.6° latitude. Unfortunately, these impacts will happen just behind Jupiter's limb, i.e., out of sight from the Earth. However, due to the rapid rotation of the planet, the impact sites will come into view only ~10 minutes later at the very limb where they will be seen "from the side". It is also fortunate that the American spacecraft *Galileo*, now approaching Jupiter, will then be "only" about 200 million km away and will have a good view of the impact sites.

On the basis of recent observations, the impact times can now be predicted to about $\pm$40 minutes. The first, rather small nucleus ("A") will hit the upper layers of Jupiter's atmosphere on July 16, 1994 at about 18:45 Universal Time (UT); the apparently biggest nucleus ("Q") on July 20, also at 18:45 UT, and the last one in the train ("W"), on July 22 at 07:00 UT.

What Is Likely to Happen at Jupiter?

The comet nuclei will hit Jupiter at a high velocity, ~60 km/sec, and a correspondingly large amount of energy will be deposited in the Jovian atmosphere. For a 1 km fragment, this is about 10^{28} erg, or ~250,000 Megatons of TNT.

When one of the cometary nuclei enters the upper layers of the Jovian atmosphere, it will be heated by friction, exactly as a meteoroid in the Earth's atmosphere, and its speed will decrease very rapidly. Depending on the size of the fragment, it may evaporate completely within a few seconds, while it is still above the dense cloud layer that forms the visible "surface" of Jupiter, or it may plunge right through these clouds (and therefore out of sight) into increasingly denser, lower layers, where it ultimately comes to a complete stop and disintegrates in a giant explosion.

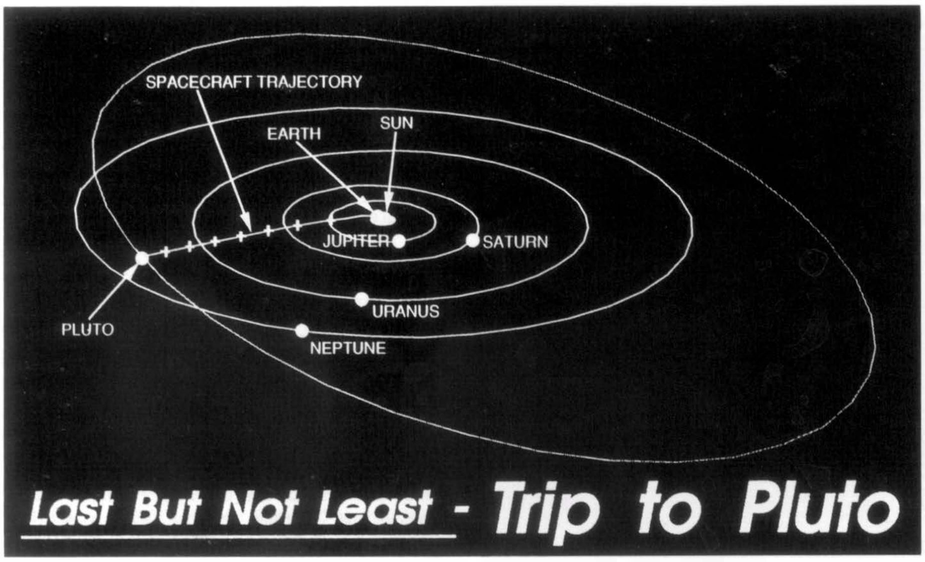
Within the next minutes, a plume of hot gas will begin to rise over the impact site due to heating of the surrounding atmosphere to very high temperatures. It may reach an altitude of several hundred km above the cloud layers and quickly spread out in all horizontal directions.

Another part of the energy will be transformed into shock waves that will propagate into the interior of Jupiter, much as seismic waves from an earthquake do inside the Earth. When these waves again reach the upper layers of the atmosphere, they may be seen as slight increases in the local temperature along expanding circle with the impact sites at their centres. The shock waves may also start oscillations of the entire planet, like those of a ringing bell.

It is also expected that there will be an interaction between the cometary dust and Jupiter's strong magnetic field. The fast-moving dust grains may become electrically charged. This will possibly have a significant influence on Jupiter's radio emission and therefore be directly observable with Earth-based radio telescope, as well as from several spacecraft, including *Ulysses*, now en route towards its first pass below the Sun. There may also be changes in the plasma torus that girdles Jupiter near the orbit of the volcanic moon Io, and some cometary dust particles may collect in Jupiter's faint ring.

All in all, this forthcoming event offers a unique opportunity to study Jupiter and its atmosphere. It may also provide a first "look" into its hitherto unobservable inner regions.

Nobody knows for sure how dramatic the effects of the impacts will actually be, but unless preparations are made a great one-off opportunity may be lost.



Pluto Fast Flyby. JPL

Part 2: Trajectories and Spacecraft Development

BY ROBERT L. STAEHLE [1]
RANDY CASSINGHAM[1]
JOHN CARRAWAY[1]
PEGGY EASTER[1]
ELAINE HANSEN[2]
PAUL K. HENRY[1]
S. ALAN STERN[3]
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2 Colorado Space Grant Consortium, University of Colorado
3 Southwest Research Institute

TRAJECTORIES [1]

A wide range of trajectory types to Pluto are available for missions using low-mass spacecraft in the late 1990s through the early 2000s.

In order to minimize flight time, launch energy (C_3) and post-launch ΔV - while also providing desirable launch and backup opportunities - direct trajectories are preferable. Other trajectories, including Jupiter and Venus gravity-assist trajectories, have been considered. Currently, a direct trajectory is baselined.

With no gravity assist requirements, a direct launch to Pluto is possible every year; gravity assist trajectories offer more limited options, longer flight times, and higher operations costs.

Only ballistic (high thrust) trajectories were considered. These include: direct, Jupiter gravity assist (JGA), two- and three-year Earth Jupiter gravity assists (2,3-ΔVEJGAs), and combinations of Venus Earth Jupiter gravity assists (VEJGAs). While low thrust (e.g. solar electric) trajectories appear attractive on paper, equipment of the capability required to perform this mission is unlikely to be available until well after 2000.

Direct

Conceptually, the simplest trajectory goes direct from Earth to Pluto. Since no gravity assists are used, there is a yearly launch opportunity. The down side of direct trajectories is that they require large launch energies; few launch vehicles can inject mass to C_3s much over 110 km²/s² (while ~>250 km²/s² is required), so additional upper stages are required. In order to have a fast flight time without augmenting the launch vehicle with upper stages, gravity assist trajectories must be used.

Direct with Jupiter Gravity Assist

Jupiter is the only outer planet with the proper orbital phasing and mass to provide a beneficial gravity assist to Pluto in the timeframe of interest. By launching to Jupiter enroute to Pluto instead of going to Pluto directly, the specific launch energy requirement is reduced to the 100-120 km²/s² range. Relative motion of Jupiter and Pluto yields only three JGA launch years per Jupiter-Pluto synodic period (roughly 12.5 years); the next set occurs in 2003-2005, with 2004 being best as flight time, post-launch ΔV and specific launch energy are minimized for a conservative Jupiter flyby constraint.

Jupiter flyby distance is constrained because of its severe radiation environment. Accumulated electron and proton radiation doses can be quite high inside 14 R_J, risking damage to both the spacecraft and instruments. Increasing the radiation "hardness" (shielding, higher reliability components, etc.) of the spacecraft and instruments will decrease the risk, but with corresponding increases in cost and mass. The constraint on Jupiter flyby distance, then, includes consideration of shielding mass, cost of rad-hard parts, and flight time. In order to keep a low-mass, low-cost spacecraft, a Jupiter flyby constraint of 15 R_J has been used for trade-off analyses. If further analysis shows a closer flyby to be possible within cost and mass constraints, significant flight time reductions could be realized, but launch still must wait for the appropriate alignment.

Two- and Three-Year ΔVEJGAs

Launch energies for the JGAs are still quite high, requiring the use of more capable and more expensive launch vehicles. An Earth gravity assist can be added to the JGA to lower the C_3 at the expense of post-launch ΔV and flight time with a two- or three-year Earth return trajectory. The spacecraft then picks up a gravity assist and heads for Jupiter for another boost to direct it to Pluto. While this strategy adds two or three years to the overall flight time, the specific launch energies are significantly lower (25-30 km²/s² with minimum post-launch ΔVs of >1 km/s for the two-year option), allowing the use of lower-cost launchers such as the Delta II or Atlas IIAS.

Venus Gravity Assists

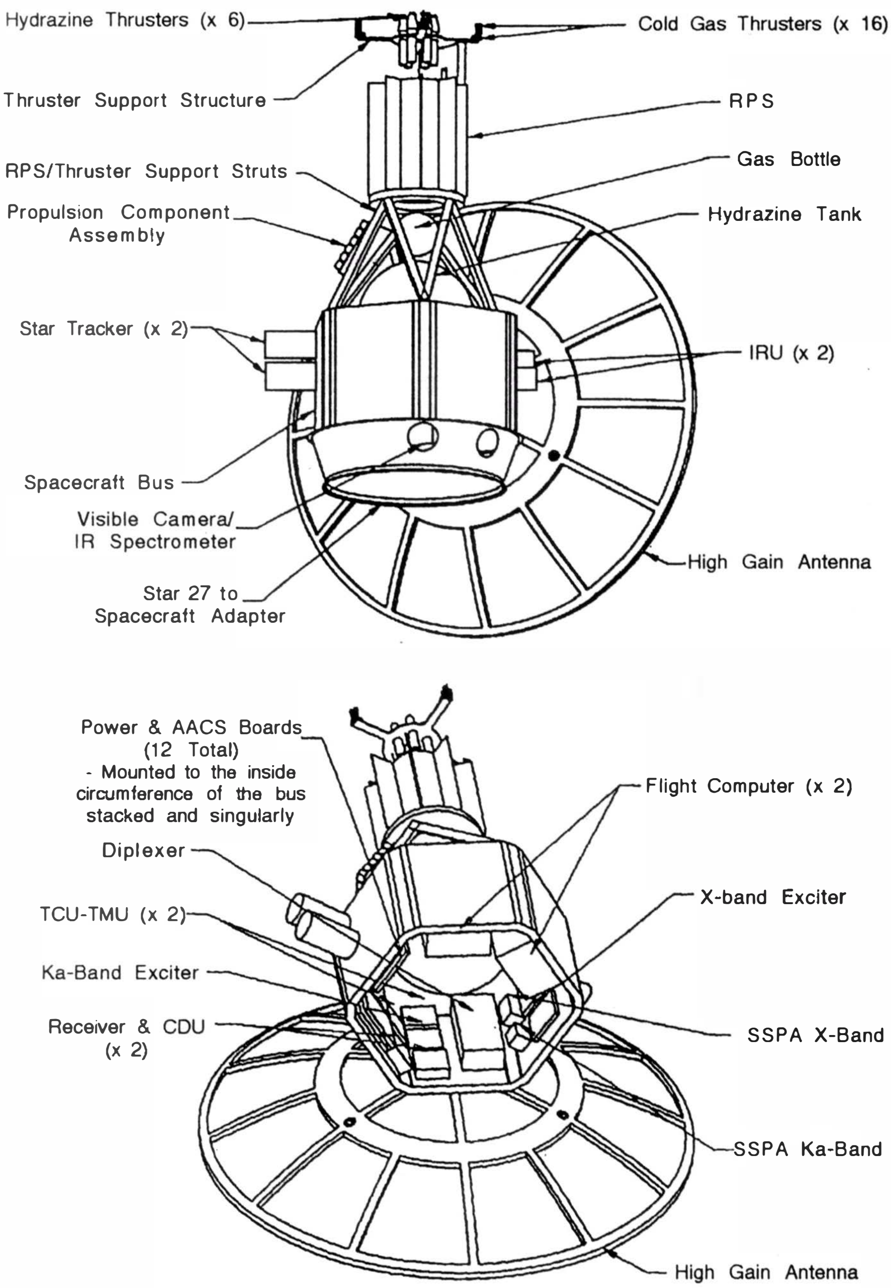
Venus gravity assists can also be added to an Earth boost flyby, as one was for *Galileo* on its VEEGA trajectory to Jupiter. The best opportunity identified so far in the timeframe of interest is a VVEJ trajectory in 2000. But there are drawbacks to this trajectory as well. First, there is a deterministic post-launch ΔV requirement of >2 km/s for the lower flight times. Second, these trajectories require perihelia of 0.7 AU or less; since solar flux scales as the inverse of distance squared, the thermal environment for the spacecraft at Venus is twice as severe as the environment at 1 AU (Earth orbit). Third, the Venus-Earth synodic period is roughly 1.5 years, which places Earth far from where it should be after only one synodic period. Therefore, launch can occur only every other synodic period, or once every three years, in order to go to Jupiter. While a VVVEGA opportunity has been identified (i.e., no flyby of Jupiter is required), a very large post-launch ΔV is required to keep the total flight time under 15 years, making the option unattractive.

SPACECRAFT DEVELOPMENT

NASA's Office of Advanced Concepts and Technology is funding research and demonstration of new technologies that will benefit the Pluto mission in meeting its goals.

Advanced Technology Insertion [2]

Within a process called Advanced Technology Insertion (ATI), the mission development team issued a request for information in November, 1992 and invited over 1200 representatives from industry, academia, and federal laboratories to look at the mission constraints of cost, schedule and reduced mass and to help identify candidate new technologies that might be included in the conceptual design efforts. Team leaders made it clear to the contracting companies that paper studies were not the desired product. The team wanted proof-of-concept hardware or software showing promise for possible inclusion into the Pluto mission within the stated mission constraints.



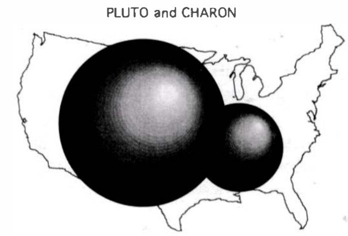
The FY93 Spacecraft configuration provides more direct loading paths, improved mass balance and lower thermal impact from the radioisotopic power sources (RPS).

Preliminary ATI work has resulted in the delivery of the first breadboard products in August 1993, with subsequent deliveries due through June 1994. New technologies for the Pluto mission will be rigorously pursued until the 1995 technology freeze.

Breadboard to Flight Hardware

The introduction of new technology necessarily means flying components for the first time. To reduce risk, "breadboard" hardware has already been built. Many early problems will be worked out at this level where components are inexpensive, different techniques may be easily tried, and reliability is not a concern. Delays introduced by problems discovered and worked out at this stage tend to be far less expensive than delays caused by problems discovered later. More than one breadboard version of a particular subsystem may be built where the benefits and risks of different implementations are uncertain. Much of the breadboard and subsequent equipment will be connected together and tested in JPL's new Flight System Testbed.

The next step is a "brassboard" spacecraft, having functional replicas of most subsystems built separately and then integrated into a partially functional spacecraft. Some subsystems (e.g., power) will not be functional; supporting lab equipment will act as surrogates. Other subsystems will be very close to flight functionality and configuration (e.g., computer and memory equipment, which might differ from flight versions only in their lack of screened electronic parts and completeness and testing of software). This brassboard will be used to work out nearly all subsystem interface details while there is still time to modify custom hardware and software.



Two flight qualified spacecraft will then be built. The first to be completed will be subjected to system-level flight qualification testing, and refurbished for the second launch. The other will be launched first. Spares will be built for a third spacecraft.

Students are providing significant support in the breadboard development. In fiscal year 1993, more than 50 students from 23 universities participated in a variety of areas, including a competition to design a prototype adapter between the spacecraft and the launch vehicle's upper stage (see Table 1). Students at the Georgia Institute of Technology won the competition; the goal was for the adapter to weigh "less than 12 kg". The students' final composite dodecahedral lattice cone adapter prototype, based on developments made by a researcher at Japan's Institute of Space and Aeronautical Sciences, weighed about 2 kg.

Mission Operations and Tracking

Students may also figure highly in mission operations. Lessons learned from using students at the University of Colorado in the operation of the Solar Mesosphere Explorer are being considered for achieving low cost, efficient operation of the Pluto mission [3]. Another operations option would integrate Pluto mission operations with the *Voyager* Interstellar Mission, operating all four (two *Voyager* plus two Pluto) spacecraft with a team only slightly larger than that required for *Voyager* alone.

Pluto mission design has considered operations from the outset. Features which contribute to low cost include:

- a spacecraft design that permits long periods of unattended operations during cruise. This enables routine cruise operations to be built around a one or two brief weekly Deep Space Network tracking and data collection passes.
- a spacecraft engineering data return strategy that exploits on-board data processing and analysis to minimize the amount of engineering data that must be downlinked and analyzed.
- spacecraft command and control capabilities that allow cruise commands to be uplinked without elaborate simulation and constraint checking.
- an encounter/flyby command sequence that is pre-planned and tested during cruise and is only refined immediately before closest approach to allow for trajectory and arrival time uncertainties.
- a large on-board memory that permits capture and storage of all the science data collected during flyby and allows its subsequent return over a limited downlink (~80 b/s over 34 m DSN stations; ~320 b/s over 70 m DSN stations)

Potential Commercial and Educational Benefits from the Pluto Mission

Advanced Technology Insertion contractors were asked to identify potential commercial and educational benefits from their participation in the Pluto mission. Excerpted comments from some of the responses include:

- Our manufacturing processes are advancing to cope with the demands of the technology of our micropackaged computer... baselined for the Pluto flyby mission. This advance in technology may well prompt our next major commercial expansion.

  Richard A. Holloway, SCI Systems, Inc.
- Pluto Fast Flyby can be expected to enhance our industrial competitiveness.... The ability to produce miniaturized high technology systems at low cost and on a short time scale will lead to domestic jobs....

  Martin Goland, Southwest Research Institute
- The efficient, light weight, compact heat-to-electricity amtec generator will be attractive for many applications, such as residential natural gas furnace operation independent of the power grid... on-site power generation... residential cogeneration... (and) use in hybrid vehicles to reduce emissions.... (S)uccess with AMTEC development will put the U.S. in the forefront of a critical new technology.

  Thomas K. Hunt, Environmental Research Institute of Michigan
- The Isogrid structures... provide light, strong, high reliability aerospace structures for spacecraft, airplanes, automobiles, and many other products, and improves the quality, reliability, safety and costs of these products.... (G)raduate students are doing most of the engineering and fabrication, (contributing) to their experience base, (giving) other students an example of how to be involved in "real" projects... (making) real contributions... (leading) to highly motivated and enthusiastic students, even among those not directly involved in the project.

  Dr Bartell Jensen, Space Dynamics Laboratory, Utah State University
- The exploration of Pluto nourishes a tremendous national sense of accomplishment. The technical challenges cannot help but provide new technology for power generation, miniaturization, propulsion, and artificial intelligence. The project has already moved into the classrooms here, in astrophysics and critical thinking classes, (which) has already helped many students think on a grander scale.

  George M. Lawrence, Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder
- One of the biggest impacts... at Georgia Tech (has been) the educational opportunities. The six students that participated in the design, building and testing of the adapter learned more about engineering than in any single course that they took.... Certain aspects of the mission could be opened up to... international collaborative research projects, which benefit not only the countries involved, but also NASA and, most importantly, the students that would be involved in the research.

  Kurt Gramoll, School of Aerospace Engineering, Georgia Institute of Technology

via routine daily DSN passes for up to a year following encounter.

Accelerated Procurement

NASA Administrator Dan Goldin demands that NASA Centers do business "faster, better and cheaper". And NASA is interested in showing the country that it is encouraging the use, and fostering the spread, of new technology. Consequently, JPL has emphasized new ideas such as the teaming with industry and universities to perform Advanced Technology Insertion (ATI) projects and mission operations, as discussed above. The Pluto Preproject is intended as a NASA showcase in the use of advanced technology.

The Pluto Preproject's ATI effort needed to move quickly to meet schedule pressures and budget cycles, thus creating the need for significant acceleration of procurements. The most important factor in accelerating Pluto procurements was the Preproject manager's recruitment of a procurement representative from JPL's Procurement division, who became an active member of the Pluto team early in the development effort. Additional negotiators from the Procurement division got involved as needed.

The procurement representative also became very involved in the ATI Request for Information, the first step in the ATI effort. The Preproject and the Procurement division had about a month to organize an industry briefing. Similarly short lead times were enabled for executing 16 ATI contracts by involving negotiators in early planning and training cognizant engineers to work with them in navigating the complex procurement process.

NASA then issued a NASA Research Announcement for the ATI science instruments and JPL initiated contracts resulting from this process. JPL issued the requests for proposals for prototype spacecraft components and executed the resulting contracts. The Preproject manager specifically did not want any "study" contracts. Consequently, all these contracts specified breadboard hardware and software of the new components. Having the procurement representative assigned as a team member resulted in all contracts being let on schedule. With several contract deliveries already complete, all work is within fixed costs negotiated at the outset.

Conclusion

Pluto's distance makes any mission there a challenge. Once considered incredibly remote, Pluto is now clearly within reach, even with significant cost, mass and time constraints. Technologies pioneered for small Earth orbiters, and

Table 1: Student Participation in Pluto Mission.

Subsystem	University	Status	Project
Telecom	U. of Michigan	complete	Build low-loss power divider
Instruments/ spacecraft system	Caltech, Northern Arizona U.	complete	Payload design, spacecraft mockup
Structure/bus	Utah State U.	in progress	Build isogrid bus structure
End-to-end info system	Central State U.	in progress	Build data flow architecture simulator
Structure	Harvey Mudd	complete	Design and build stack adapters
Flight computing	U. of Baltimore	complete	Recommend data compression
Propulsion stack	Caltech	in progress	Build stack motor mockups
Flight computer	Stanford U.	in progress	Build low-power CMOS chip
Trajectory /science	Occidental	in progress	Animation of flyby
Trajectory	Purdue U.	complete	Pluto and follow-on trajectories
Mission	Southampton (UK)	complete	Pluto mission alternatives
Computer	UCLA	in progress	develop computer architecture
Spacecraft systems eng.	U. Texas (Austin)	in progress	Shuttle requirements
Spacecraft systems eng.	RPI	complete	telemetry requirements
End-to-end info system (EEIS)	Trinity	complete	EEIS/testbed architecture
EEIS	U. Colorado (Boulder)	in progress	Ground data system/EEIS
Adapter competition	see below	complete	Design and build vehicle/spacecraft adapter
	U. W. Virginia		
	Manhattan College		
	Georgia Tech		(Winner)
	U. Naples (Italy)		
	Tuskegee U.		
	U. Central Florida		
	U. Maryland		

A full scale model of the Pluto Mission FY92 spacecraft configuration was built by university students. Another mockup of the newer FY93 design, including the upper stage and spacecraft adapters, is currently under construction by students.

NASA/JPL Photo CAROL LACHATA

advanced technology development supported by NASA, universities, and industry, enable spacecraft mass and operations cost reductions far below what was thought possible as little as two years ago. Present efforts are focused on demonstrating the viability of new subsystem and instrument components, and an innovative development, test and operations approach through procurement and testing of proof-of-concept hardware and software. As mission resource constraints grow tighter, recent work represents a head start toward reaching aggressive goals of life cycle cost and technology improvement within a first-class scientific mission.

Arguments for a visit to Pluto and Charon have become more compelling with *Voyager's* successes - and we *should* complete the initial reconnaissance of our Solar System. What measurements we have been able to make from Earth render Pluto and Charon an enigmatic pair, and there is no doubt that additional important pieces to the puzzle of the Solar System's formation will be revealed with a successful mission to Pluto.

Acknowledgements

Work described here was performed at the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration, and at Pluto mission partner and contractor organizations. NASA's Office of Space Science, and NASA's Office of Advanced Concepts and Technology, sponsored this work, as did sponsors of partner organizations. The authors acknowledge numerous contributions from other team members in government departments, federal laboratories, industry, academia, NASA and JPL.

References

1. S. Weinstein, "Pluto Flyby Mission Design Concepts for Very Small and Moderate Spacecraft," AIAA-92-4372, AIAA/AAS Astrodynamics Conference, Hilton Head Island, South Carolina, August 10-12, 1992.
2. Robert L. Staehle, *et al.*, "Pluto Mission Progress: Incorporating Advanced Technology," Seventh Annual AIAA/ Utah State University Conference on Small Satellites, Logan, Utah, September 13-16, 1993.
3. Elaine Hansen, "Lowering the Costs of Satellite Operations: Lessons Learned from the Solar Mesosphere Explorer (SME) Mission," Paper AIAA-88-0549, AIAA 26th Aerospace Sciences Meeting, Reno, Nevada, January 11-14, 1988.

SETI Funding

We are pleased to hear that the search for extraterrestrial intelligence is to go on in spite of Congress cancelling funds for NASA's newest SETI project. Continuation of the work of the SETI Institute now depends on support by private donations from industrialists and interested individuals.

The Society, which has long supported SETI concepts through its meetings and publications, has received the following letter from Arthur C. Clarke:

> I am deeply distressed to hear that the work of the NASA SETI group is no longer to be funded by the United States Government.
>
> One of the most important of all philosophical questions is whether there are other intelligent lifeforms in the universe, whom we may one day contact.
>
> The SETI Institute in California is attempting to raise private funds to carry on the targeted search that NASA must now abandon.
>
> This endeavour is far too important to be allowed to drop and, as it is for the benefit of every country in the world, we should all support the SETI Institute's noble cause in any way we can.
>
> I would therefore suggest that the British Interplanetary Society should lead the support from the UK and am arranging for a cheque for £5000 to be forwarded to you for this purpose.

The SETI Institute has written to the Society saying:

> Thank you very much for your transmittal of the £5000 gift from Arthur C. Clarke. The gift is very much appreciated, and will be put to good use.
>
> The Institute's goal is to continue the Targeted Search portion of the HRMS Project using private funds. Even though the Institute has been tremendously fortunate in receiving donations thus far, they still have to raise a considerable sum (approximately US$3 million before mid-1995) to keep the project alive and welcome support from all interested parties.

Members wishing to support this work should send directly to the SETI Institute at 2035 Landings Drive, Mountain View, Ca 94043 (Phone 415-961-6633, Fax: 415-961-7099).

AIAA Award for Fellow

We are pleased to learn that Dr Burton I. Edelson, a Fellow of the Society, is a recipient of the AIAA 1994 International Cooperation Award.

The award is made to individuals for significant contributions to US programmes involving international cooperation in space, aeronautics or both.

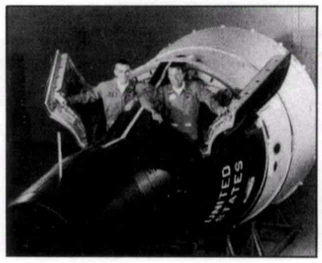
Burt's career began with an assignment to the National Aeronautics and Space Council at the White House and he subsequently participated in international programmes in the US Navy, at Comsat and at NASA. He is now a Research Professor at The George Washington University.

Long Service Tribute

Gordon Thompson, who, following the recent Council Ballot, relinquishes his Council membership, has received a vote of gratitude by the Council for almost 47 years of service that he has given to the Society.

Gordon joined the Society in 1946 and has been an active Committee member over many years. He was editor of the Journal of the British Interplanetary Society from 1955 - 1964 and became President for the years 1980 - 1982.

We wish him well and look forward to seeing him at many future Society functions.



"Crew Schedule" Competition Winners

First Prize:

Mr N.A.F. Bernard	UK

Consolation Prizes:

Mr H. Duncan	UK
Mr L.M.O. Passmore	UK
Mr C. Toomer	UK
Mr P. Turpeinen	Finland

The correct answers are:
CD; EB; GH; AJ; KL; MF; OP.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: All Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Admission is by ticket only. Members should apply in good time enclosing a sae. Subject to space being available each member may also apply for a ticket for one guest.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight/JBIS*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

6 April 1994 — 7 - 8.30 pm

Space Policy

Frances Brown

This talk will focus on the different external factors that have always shaped space policy formulation - sometimes to the detriment of scientific objectives - and will look at how current space policy is being affected by political change and economic conditions, using the developments taking place in various countries' space programmes as examples.

4 May 1994 — 7-8.30pm

The STRV Project: 'Two UK Spacecraft to Brave Hostile Orbit so Others can Live Longer

K. A. Ryden

Two small satellites built by the Defence Research Agency, Farnborough are awaiting launch on an Ariane vehicle: they will be spending their relatively short lives in an exceptionally severe orbital environment. The purpose of their mission is to answer questions about the true effectiveness of a wide range of new and untried space technologies. These technologies hold the promise of extending the performance, lifetime and reliability of future space systems beyond that currently achievable.

This lecture will describe the entire mission including the design of the two 'STRV' satellites, the environment which they will encounter and the new technologies and experiments which they will be carrying.

1 June 1994 — 7 - 8.30 pm

The Microlight Solar Sail

C. Jack

Sunlight exerts less than one kilogram force per square kilometre. Deploying and controlling the large area of fabric necessary to convey a conventional spacecraft would be hard. This is why, despite the potential of the idea, no such craft has actually been launched.

Recent advances in microelectronics make possible a quite different concept: a tiny rigid sail just a few metres in diameter which could be controlled purely by electronics, without moving parts. The key components of the craft will be a tiny CCD camera developed at Edinburgh University which can act as both attitude sensor and data gathering device, high performance solar cells providing a few watts of power for control and communication, and a radio which uses the sail itself as a directional antenna.

The craft will be highly manoeuvrable, compared to a large sail and will be capable of some ambitious missions, including rendezvous with near-Earth asteroids.

6th July 1994 — 7 - 8.30 pm

Life Support in Space and Lessons for Earth

R. Huttenbach

The talk will describe the features of systems used to sustain astronauts when they live in space. These include the revitalisation of the air they breath, the supply of water and food they consume and the management of the waste they produce. All must be integrated into loops that can be open or regenerative. Examples of open loop missions (Apollo, Shuttle) and ones with partially closed systems of life support (Mir and Space Station Freedom) will be presented. Beyond this, journeys into space will require a greater degree of material closure. These will utilise plants and biological components to produce food from recycled nutrients.

The technology of biological life support and the evaluation of how closed a system should, or can be, provide important insights into how we might use resources on Earth.

7 September 1994 — 7 - 8.30 pm

What Must We Change For Low Cost Space: Management, Politics or Technology

C.J. Elliott

Early space programmes were cheap and effective. We have now reached the position where a mission like Envisat takes 15 years and costs 1500MAU, justified on the grounds that large missions bring an economy of scale. This lecture examines the drivers that force up the costs of space missions and seeks different ways of behaving that might lead to a virtuous spiral of falling costs and shorter development programmes.

6 October 1994 — 7 - 8.30 pm

The First Manned Lunar Landing Spacecraft: Its Design, Manufacture, Ground Test and Mission

R. Fleisig

This paper uses the development, production, testing and flight of the first successful manned lunar landing spacecraft as a point for current studies of future spacecraft to be used for a return to the Moon. Apollo trajectories are identified for each mission phase and lunar surface temperatures and other factors considered.

SYMPOSIA & CONFERENCES

4 June 1994 — 10-4.30 pm

Soviet Astronautics

* * *

23 June 1994 — 10-4.30 pm

Space Industrialisation as a Response to Global Threats

Papers to be presented at this Symposium include: 'Space Industrialisation as a Response to Global Threats - An Overview', 'The Exploitation of the Moon to Substitute Terrestrial Resources', 'Sub-Orbital Tourism - The Key to Space Industrialisation', 'The Space Option and Our Future: Some Considerations on the Thermal Burden'.

15 September 1994 — 10-4.30 pm

Space Transportation and Infrastructure

This one day symposium will include papers on 'The Skylon Spaceplane', 'The Architecture of the Space Infrastructure with Advanced Spaceplanes'.

9-14 October 1994

45th IAF Congress "Space and Cooperation for Tomorrow's World"

The 45th Congress of the International Astronautical Federation will be held in Jerusalem, Israel, October 9-14, 1994. There are 98 technical sessions planned.

Offers of papers for Society Symposia would be welcome. Please send Title and Abstract and indicate which Symposium to the Executive Secretary. *Advance Registration is necessary. Limited undergraduate student concessions available on request.* Registration: Forms are available from the Executive Secretary. Please enclose a sae and indicate the Symposium you wish to attend.

LIBRARY

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

Elections to Council

The Report of the Scrutineers on the ballot papers counted up to and including 31 January 1994 was as follows:

Number of Papers received were 665, three of which were rejected for late arrival. There were no spoilt Papers.

The names of the candidates and the number of votes cast for each was as follows:

Position	Name	No. of Votes
1.	C S Welch	552
2.	G V Groves	541
3.	J Harlow	528
4.	P T Thompson	515
5.	R L S Taylor	369
6.	R Turnill	325
7.	G V E Thompson	260

The five candidates receiving the highest number of votes and who were accordingly declared elected were:

C S Welch, G V Groves, J Harlow, P T Thompson, R L S Taylor

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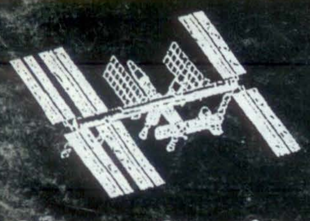
Spaceflight

The International Magazine of Space and Astronautics

Crew of Endeavour's Mission STS-59



- Radar Imaging
- Outer Solar System
- Mir
- Shuttle
- Milstar Satellite

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A 50 minute video of Arthur C. Clarke describing his work - past, present and future.

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The question and answer session is led by astronomer and "Sky at Night" TV personality Patrick Moore and by lunar astronaut Buzz Aldrin.

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The video pictures are exclusively of Arthur C. Clarke, with audio presentations by other participants.

Price: £9 (US$16) plus p&p.
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To place your order please send your remittance to:
The British Interplanetary Society,
27/29 South Lambeth Road,
London SW8 1SZ.

STS-49 Mission Highlights

The details of this flight by the Shuttle Endeavour, 7-16 May, 1992, are well covered, e.g. the preliminaries of suiting-up, the White Room, entry to orbiter, removal of gantry, count-down, engines start, lift-off, and detailed operations during the flight. A principal aim was to retrieve the Intelsat VI satellite which had previously failed to reach synchronous orbit. Though more difficult than expected, it was achieved and sent on its way. A second aim was to practice basic space station assembly work by Extra-Vehicular Activity (EVA). *1hr 50 mins*

STS-46: Mission Highlights

This features the 12th flight of Atlantis with a crew of seven. Flight objectives included the deployment of the European Recoverable Satellite (Eureca) using the Robot Arm operated by Mission Specialist Claude Nicollier and the first, though unsuccessful, launch of a Tethered Satellite. *50 mins*

STS-54: Mission Highlights

The flight of Endeavour with a crew of five features splendid scenes of the launch of theTracking and Data Relay Satellite (TDRS) against an Earth backdrop and experiments with Biopack. Onboard crew activities include a variety of physical exercises. The video concludes with spectacular EVA and Earth shots. *50 mins*

Apollo Missions 4, 5 and 7

Apollo 4 Mission: Covers the launch of the mighty Apollo/Saturn V unmanned space vehicle which reached an altitude of 11,232 miles. As Apollo 4 climbs toward this peak altitude, a camera pointed out the spacecraft window, records views of the Earth. The Service Module propelled the Command Module into reentry velocity of approximately 25,000 miles per hour. *15 mins*

Apollo 5 Mission: Follows the successful testing of the Lunar Module, the spacecraft in which man will make his first landing on the Moon. Tracking stations around the world track its position with pinpoint accuracy as the Mission Control engineers test the many systems onboard. Lunar Module 1 - not designed to return to Earth - tumbles on through space until destroyed by the atmosphere of the Earth. *17 mins*

Flight of Apollo 7: Records life and work on the first manned flight of the Apollo series. Apollo 7 was designated to make the essential test of the Apollo spacecraft before the ambitious lunar-orbital mission could be attempted. All systems respond perfectly. The first television from space highlights the film. *14.5 mins*

Total running time 46.5 mins

The Gemini Collection

Five cassettes covering Gemini missions (listed below) may be purchased as a set at the special reduced price of £45 (US$90)

The Apollo Collection

The Apollo Collection of videos, Apollo 11-17, may be purchased as a complete set at the special price of £60 (US$120)

Please send me the following cassette(s): Please Tick

❑ SPACE '93 Satellite Link-up	£9 (US$16)
❑ Legacy of Gemini	£11 (US$20)
❑ Apollo 4, 5 and 7	£15 (US$27)
❑ Apollo 8: Go For TLI	£11 (US$20)
❑ Apollo 9: Three to Make Ready	£11 (US$20)
❑ Apollo 10: To Sort out the Unknowns	£11 (US$20)
❑ The Eagle has Landed: The Flight of Apollo 11	£11 (US$20)
❑ Apollo 12: Pinpoint for Science	£11 (US$20)
❑ Apollo 13: "Houston... We've got a problem"	£11 (US$20)
❑ Apollo 14: Mission to Frau Mauro	£11 (US$20)
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❑ Apollo 16: Nothing So Hidden	£11 (US$20)
❑ Apollo 17: On the Shoulders of Giants	£11 (US$20)
❑ The Apollo Collection (Apollo 11 - 17)	£60 (US$108)
❑ STS-46: Mission Highlights	£15 (US$27)
❑ STS-54: Mission Highlights	£15 (US$27)
❑ STS-49 Mission Highlights	£18.50 (US$34)
❑ Time of Apollo	£11 (US$20)
❑ The World Was There	£11 (US$20)
❑ Skylab: The First 40 Days	£11 (US$20)
❑ Skylab: The Second Manned Mission	£15 (US$27)
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Spaceflight

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Space Station News

Space Music

Features

News & Events

Space Miscellany

Front Cover: **The crew of Endeavour on shuttle mission STS-59. Sidney M. Gutirrez, mission commander, is standing (right), along with Kevin P. Chilton, pilot. Others, left to right, are Linda M. Godwin, payload commander; and Thomas D. Jones, Jerome (Jay) Apt and Michael R. (Rich) Clifford, all mission specialists.** NASA

Vladimir Titov (left), who is due to fly on the STS-63 rendezvous mission to Mir in January 1995, at NASA's payload facility at Cape Canaveral with Sergei Krikalev. NASA

Shuttle to Mir

Almost 20 years ago, on July 17, 1975, after many months of intense preparation the Soviet Soyuz-19 and the American Apollo 18 spacecraft rendezvoused and docked in Earth orbit. Astronaut Thomas Stafford and cosmonaut Alexei Leonov exchanged the first international handshake in space through the open hatch of the Soyuz. For 44 hours three American and two Soviet space explorers worked and lived together in space.

Today the Americans and the Russians are embarking on a new era of cooperation in space, which represents the beginning of a fresh chapter of piloted space flight. Up to ten Shuttle missions will dock with the Russian space station Mir over the 1995 - 1997 time frame.

BY ANNE VAN DEN BERG, FBIS
The Netherlands

A New Era

NASA Administrator Daniel Goldin and Russian Space Agency (RSA) Director General Yuri Koptev signed the agreement on Shuttle flights to Mir in Moscow on 16 December 1993.

The new protocol expanded the terms of the Human Space Flight Cooperation Agreement, which was ratified on 5 October 1992. Within its framework cosmonaut Sergei Krikalev was sent into orbit as a crewmember of the STS-60 mission on 3 February 1994 and astronaut-doctor Norman Thagard will be launched for a three months flight on Mir, starting on 3 March 1995.

Also agreed was an additional Russian cosmonaut flight on Space Shuttle mission STS-63, scheduled for launch on 26 January 1995, during which the Shuttle will perform a rendezvous with the Mir Space Station and will approach to within a safe distance. Currently in training for this mission is cosmonaut Vladimir Titov.

This continued and enhanced human space flight cooperation between NASA and the RSA is supposed to culminate with the building and operating of NASA's proposed much more ambitious International Space Station later this decade.

Goals

At meetings in Houston, top NASA and RSA officials settled most of the issues standing in the way of the ten flight Shuttle-Mir docking programme. This was despite tight budgets, that could have forced both space powers to scrap plans, resulting in fewer missions.

To do the ten-flight scenario, two Shuttle orbiters need to be modified for the Mir dockings. It was decided right away to equip the Shuttle Atlantis with an NPO Energiya-built androgynous docking assembly and recently it was announced that NASA would fit Shuttle Discovery with a Mir docking module as well in order to meet the full complement of the programme. Following this, already-assigned Shuttle payloads were shifted to other vehicles and about half of NASA's astronauts are already taking Russian lessons. Many will soon travel to Russia's Star City Cosmonaut Training Centre near Moscow to get ready for the missions, while Russian cosmonauts will depart for the Johnson Space Center, Houston to undergo Shuttle familiarisation training.

Under the terms of the docking programme, American astronauts will log a cumulative two years in Earth orbit aboard the Mir station. This will give the Americans direct scientific and managerial experience with long-duration space missions.

Two three-month stays and three six-month stays of American astronauts (flying one at a time) will be conducted. The first three-month stay will be the mission of Norman Thagard, who will be launched to Mir together with two cosmonauts aboard Soyuz TM-21 and will be taken back to Earth by the crew of the STS-71 mission. All four other astronauts to fly to Mir will be ferried up and down by the Shuttle.

The Shuttle-Mir docking missions will emphasize a broad range of scientific and technological research, including utilisation of the Mir Spektr and Priroda modules. Critical systems needed for the proposed International Space Station (such as life support systems, solar power devices, space suit elements and other technology) will be developed and tested, and research in general materials science and medicine will be carried out.

Another main purpose of the programme is the upgrading and extension of lifetime and capabilities of the ageing Mir outpost, which was launched eight years ago. The Americans will be carrying equipment up to Mir to extend its life by a couple of years.

The Flights

Details on the flights (nine-day missions, except for the fifth mission, which will last 16 days) are still preliminary, however, NASA documents provide an outline:

Flight 1: STS-71, set for launch May 30, 1995. Shuttle Atlantis is to dock with Mir. Astronauts and cosmonauts will conduct experiments in both the Mir station and a Spacelab module in the Shuttle's cargo bay.

Also a crew exchange will take place. Atlantis will bring the next Russian Mir main crew to the station (Anatoli Solovyev and Nikolai Budarin), relieving the then resident cew (Vladimir Dezhurov, Gennadi Strekalov and US astronaut Norman Thagard) who will have been aboard Mir for three months.

Flight 2: STS-74, set for launch October 26, 1995. Atlantis is to dock with Mir. NASA will ferry new solar panels along with a new docking adapter extension that will allow Shuttles to dock at a more stable location. US and Russian spacewalkers will attach the tunnel-like docking extension to a Mir station port. All future Shuttle missions to Mir will dock there.

Flight 3: STS-77, set for launch March 21, 1996. Atlantis, with a Spacelab module in the cargo bay, is to dock with Mir. Elements of a new environmental control and life support system will be ferried to the station and Russian spacesuits will be tested.

Earlier, plans had been made for a launch in late December 1995 (STS-76) for the purpose of bringing back to Earth a European Space agency astronaut (Christer Fuglesang or Thomas Reiter)

after a mission of 135 days aboard Mir.

Flight 4: STS-79, set for launch June 27, 1996. The first Discovery docking mission to Mir. A second US astronaut will be ferried to Mir for a three-month stay aboard, during which a variety of US space science experiments will be conducted. Earlier plans manifested the flight as STS-78.

Flight 5: STS-81, set for launch September 6, 1996. Atlantis is to dock with Mir. The third US astronaut will be dropped off at the Russian space station to conduct science experiments, replacing the astronaut from Flight 4. A variety of life support systems developed for the planned International Space Station will be tested on this flight. Earlier plans manifested the mission as STS-79 and STS-80.

Flight 6: STS-82, set for launch November 7, 1996. Discovery, equipped with a Spacelab module, is to dock with Mir. A Shuttle crew will begin a spacesuit development programme and carry out tests.

Flight 7: STS-84, set for launch January 30, 1997. A fourth US astronaut will be launched aboard Atlantis to Mir to conduct science experiments. Earlier plans manifested the flight as STS-83.

Flight 8: STS-86, set for launch April 17, 1997. Discovery is to dock with Mir. It will also be the fourth Spacelab flight to Mir. The fifth and final US astronaut will be ferried up to Mir to replace the astronaut launched to the Russian Space Station on Flight 5.

Flight 9: STS-88, set for launch June 26, 1997. Atlantis is to dock with Mir. A Shuttle crew will visit Mir to carry out various US science experiments and other experiments aimed at developing equipment for the planned International Space Station. The fourth Mir astronaut will be taken back to Earth. Earlier plans manifested the mission as STS-87.

Flight 10: STS-90, set for launch October 2, 1997. Discovery is to dock with the Mir station. The Spacelab module will be aboard. The Shuttle crew will visit Mir to conduct science experiments and to bring the fifth Mir astronaut back to Earth.

Crews have not been selected for the Mir docking missions. However, astronaut Kenneth Cameron is expected to command one of the early missions to Mir. Cameron has been selected to manage NASA operational activities at Star City (where he will supervise NASA astronaut training) and at the Russian control centre at Kaliningrad. He left for Russia on February 23, 1994. Bonnie Dunbar (Norman Thagard's back-up) is expected to be a crewmember on one of the missions, too. Further speculation centres on Steven Nagel and Story Musgrave.

As for the Russian participants only the crews taking part in the first crew exchange have been chosen (Dezhurov, Solovyev, Strekalov and Budarin). Other cosmonauts in line for selection are expected to be Vladimir Titov, Aleksandr Kaleri, Sergei Krikalev, Gherman Arzamazov and Valeri Korzun. ■

International Space Station

US participation in the International Space Station has yet to receive the approval of Congress. Previous Space Station designs have met with considerable opposition in Congress, on the last occasion being only narrowly approved. The present Space Station programme can be expected to be no exception. Congressional voices are already on the attack.

With Russia now added to the international partners, new arrangements need to be set up and agreements formalised. Events have been fast moving over the last months and particularly during the last few weeks.

NASA has been spear-heading planning of the new programme in all its aspects of design, scheduling, contracting and costing. Confidence building is also a task that NASA faces, both with its international partners and its own national bodies, particularly Congress. As in many politically active situations, time is of the essence. NASA has been pulling out all the stops in an effort to get the go-ahead.

Reports and news items are reaching us at the *Spaceflight Office* from many quarters. Taken together, they go some way to depict the current tempo and diversities that surround the Space Station programme. We present a selection here and on the next four pages.

Constructing the New Space Station

Documents, signed by the Prime Minister of Russia Viktor Chernomyrdin and the US Vice-President Albert Gore in December 1993, provide for Russian-American cooperation in space and the creation of a large orbital space station.

Space projects become ever more expensive, and even the richest countries cannot finance them alone. It is for this reason that the American orbital station Freedom remained on paper for so long. Russia has amassed unique experience in this sphere and its Mir station, built long ago, is still in operation. Russian specialists have designed a new station, Mir-2, but at the present time there is no finance available for its construction and launch. The pooling of efforts will make it possible to avoid duplication of programmes, something that is wasteful for all interested parties.

The Boeing corporation of the USA and the Russian scientific and industrial association Energiya will be the general contractors for the work. The construction of the station will begin in 1997 with the launch of a Russian Proton rocket carrying a "space tug". An air-tight basic unit, which is currently being built at the Khrunichev plant in Moscow and which was to form the basis of Mir-2, will be docked with it. A docking module will be mounted on this unit for linking up with the Soyuz rescue spacecraft. A berth for the American Shuttles will be built on the other side of the "tug".

The Shuttles will link up with the station by means of modern docking units of Russian make. For this purpose Rockwell International corporation has concluded a contract worth $18 million with the Energiya scientific and industrial association. Later, the orbital station will include a laboratory module for conducting scientific experiments in weightlessness and a truss construction.

The next stage will begin at the end of 1998 when the construction of a large power truss will start at the station. The solar plant will consist of a mirror for concentrating the sun rays and turbogenerators for utilising the heat.

During the construction of the station Russia will contribute its expendable two- and three-stage rockets with the Progress transport freight spacecraft and the USA its reusable winged shuttles. The total mass of the future space structure - about 200 tons - shows the size of the future freight traffic that will be involved.

The new station will at first receive three cosmonauts and by the year 2000 the number should be six. By that time, laboratory modules and additional living quarters will have been added and the total air-tight volume will have reached 1,200 cu m.

The financing of the joint station will not exceed the scale of expenditure previously planned by the participating countries. It is true that certain redistributions of funds will take place. For instance, the USA will be paying $100 million annually to Russia over the next four years. The pooling of resources will substantially reduce funds previously earmarked by the countries for their own manned space programmes. For instance, Russia will be able to cut this expenditure by 50-60 percent.

YURI KOLESNIKOV, RIA NOVOSTI

Space Station Transition

On 1 February NASA passed a major milestone in its Space Station Program when agency and contractor officials signed documents that marked the end of the Space Station Freedom Work Package contracts, thus concentrating responsibility for the design, development and integration of the programme under a single prime contract with Boeing Defense and Space Systems Group, Seattle.

"This event is just one indicator that work on the International space Station is on track and moving ahead", said Randy Brinkley, Manager of the NASA Space Station Program Office, Houston. "A large group of people has been working very hard over the last several months to make the transition from the Freedom programme to our current redesigned programme. Because of their efforts, we are well on our way to having an international laboratory in space".

One of the documents was a major modification to the 15 November 1993 letter contract between NASA and Boeing. This modification changes Boeing's scope of work from a transitional contract to a hardware design and development contract. A final contract between NASA and Boeing will be drawn up later this year.

Boeing was designated as the prime contractor in August 1993 following a recommendation by the Station Redesign Team to strengthen Space Station integration by realigning the separate hardware development contracts under a single prime contractor. The prime contractor, Boeing, will be responsible for the design, development, integration, test and delivery of the Space Station vehicle. After contract realignment, Boeing will be responsible for the management of two major subcontracts with McDonnell Douglas and Rocketdyne. Overall, the agreements signal the end of the transition from the Space Station Freedom Program to the redesigned Space Station Program.

Shuttle Orbiter Modifications

Space Shuttle Director Tom Utsman announced on 15 March that NASA intends to accomplish all major modification work on the Space Shuttle fleet at Rockwell International's facility in Palmdale, California.

Several factors have influenced this decision including the expanding requirements associated with the Russian cooperative effort, the ability to support future operations of the International Space Station and the desire to process the Shuttle orbiters for flight at the Kennedy Space Center in the most efficient manner possible.

"This decision will allow the Shuttle orbiter modification to be performed by approximately 300 workers located at Palmdale while the 7,000 KSC member team can concentrate their efforts on safe and efficient vehicle processing", Utsman said.

Space Shuttle Atlantis, undergoing major modification work at Palmdale to allow it to dock with the Mir Space Station, is scheduled to return to KSC in June in preparation for the STS-66 mission in September. Following that mission, Atlantis will fly the first docking mission with Mir on Shuttle Mission STS-71.

Future major modification work scheduled at Palmdale will include preparing a second orbiter, Discovery, to have the ability to dock with the Mir Space Station so that it can help support the first phase of the new Russian cooperative effort.

Discovery also is scheduled to have installed:

(1) The initial work associated with the Multifunctional Electronic Display System (MEDS);

(2) A fifth cryogenic tank set;

(3) The same Mir modifications as on Atlantis so that Discovery can support Phase One Russian cooperative efforts; and

(4) The removal of the internal airlock and installation of a new external airlock to support the future International Space Station.

The decision to make Discovery capable of Mir docking will have a slight impact on the near-term Shuttle manifest. Columbia is next in line for major modification work and will be sent to Palmdale following its next mission, the STS-65 mission. The STS-67/ASTRO-2 mission, originally scheduled for Columbia in December 1994, will be flown aboard Endeavour in early January 1995. Columbia is expected to arrive at Palmdale in September 1994 with work projected to last seven to eight months. Among the improvements scheduled for Columbia is the initial work associated with the MEDS system.

Discovery will be sent to Palmdale following the STS-70 mission. It is expected to arrive at Palmdale in September 1995 where it will remain for seven to eight months. Following modification, it will fly a docking mission with Mir on Shuttle Mission STS-79 in June 1996.

To obtain the maximum efficiency while the modification work is underway, normal inspections and evaluations associated with the Orbiter Modification Down Period (OMDP) also will be performed at Palmdale. Each orbiter is required to go through an OMDP about every 3 years so that technicians can make structural evaluations on the various shuttle systems.

Shuttle Tank

NASA is ordering a new lighter-weight External Tank so that the space shuttle can reach the high inclination orbit of the space station, which is one that is easily reached from Russia. The same orbit is achievable from Cape Canaveral but at a cost of about one-third in cargo-carrying capacity. The tank will be 8,000 pounds lighter than the one in use since the shuttle programme began in 1981.

The existing contract for the tank with Martin Marietta will be modified, enabling the contractor to make the required changes. The first Super Lightweight Tank is scheduled for delivery in 1997, with External Tank-96 projected as the first aluminium lithium tank. Testing of the new configuration will be accomplished at MSFC. The programmed development cost is estimated at $172.5 million. Each Super Lightweight Tank produced will cost approximately $59 million.

Russia - A New Partner

Decision to be Implemented

On 18 March 1994, at a meeting in Paris, the signatories of the multilateral Intergovernmental Agreement (IGA) on cooperation in the design, development, operation and utilisation of the future International Space Station welcomed Russia as a new partner and began the negotiations that will establish its role.

The meeting was attended by the 11* ESA Member States participating in the Columbus Programme and the Manned Space Transportation Programme (MSTP) and by the United States, Canada, Japan and the Russian Federation.

With the advent of Russia as a new partner, some amendments will have to be made to the formal agreements over the months ahead, in order to carry out the space station programme. A joint statement, summarising the results of the meeting, appears on the opposite page.

After the meeting, Mr Jean-Marie Luton, the ESA Director General, said: "Cooperation on an unprecedented scale will now develop and I am sure that, like all the other partners, Europe will reap both political, industrial, scientific and technological benefits from it. This is a project in which we must play our full part and we are now working on the definition of our contribution, based on the Columbus element and the cargo and crew transport systems that will be launched by Ariane 5".

*Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom.

ESA Re-Organisation

The agonising over ESA's programmes is (at least for the moment) over, as the governments of the member states agree to a largely "wait and see" policy of studies for ESA's manned space flight programmes. This is more than understandable in the prevailing economic climate and given a degree of uncertainty about the future plans for the International Space Station in the United States and Russia.

The change in emphasis has meant a look at the internal structure of ESA and, as a result, a new structure covering the manned space flight and launcher programmes was set up at the ESA Council Meeting on 22-23 March.

The Manned Spaceflight and Microgravity Directorate will be responsible for studies that could ensure the nature of Europe's participation in the International Space Station and negotiations of the arrangements for cooperation with the United States and other international partners. Mr Jörg Feustel-Büechl has been appointed Director. There will be a *Launcher Directorate* that will be responsible for the remaining Ariane-5 programme and future launchers. Mr Fredrik Engström has been appointed Director.

Forthright Views on International Cooperation by ESA Director General

Taking as his theme *Space - Open to International Cooperation*, **M. Jean-Marie Luton, Director General ESA, explained to a packed audience some of the elements that had led to success and failure in cooperative ventures in the last three decades in space. The occasion was the R.J. Mitchell Memorial Lecture delivered in Southampton on 2 March.**

Success had invariably followed when those who cooperated had accepted that there should be a central authority, rather than putting together elements from individual countries. He could quote the early successes of the European Space Research Organisation (ESRO) and the failure of its sister organisation the European Launcher Development Organisation (ELDO) in support of his arguments.

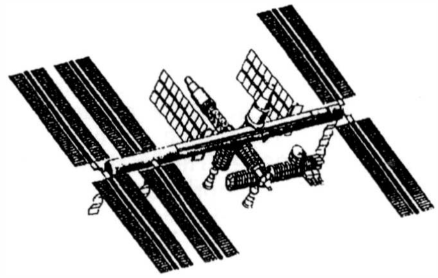
At the present time, while many excellent cooperative programmes had been possible, particularly with the United States, he pointed out that the method by which NASA had to apply annually for its budget, with doubts on occasion about the political support from Congress, made it extremely difficult for other countries or agencies with longer-term fiscal policies to plan for cooperative ventures.

While he remained optimistic about the future and especially about manned space, he drew a parallel with the developments in ELDO and those being experienced today with the planning of the International Space Station.

Space Station Moves Ahead on Schedule

Plans for the International Space Station were revealed at the System Design Review (SDR) on 24 March at the Johnson Space Center. Present, in an unprecedented show of support, were participants from NASA, the Canadian Space Agency, the European Space Agency, the Italian Space Agency, the Japanese Space Agency, the Russian Space Agency, the prime contractor Boeing and Tier I subcontractors Rocketdyne and McDonnell Douglas.

Space Station Director Wilbur Trafton said, "The Space Station team has just conducted a comprehensive review of the requirements, configuration and the maturity of the station's technical definition. We now have a solid baseline for the programme. We have an executable schedule with costs that maintain acceptable reserves within our budget cap". Refinements to the cost and programme schedules were also presented.



Baseline Configuration

The completed International Space Station uses approximately 75 percent of Space Station Freedom hardware and consists of several US elements including the integrated truss, habitation module and laboratory module; the Russian science power platform, service module and functional cargo block vehicle; the ESA laboratory module; Japanese experiment module and exposed facility and the Canadian remote manipulator system.

The station will operate at an altitude of approximately 444 km and will orbit at a 51.6 degree inclination which will offer better Earth observation opportunities. The International Space Station increases crew size from four to six. It will have 33 standard user racks for science operations.

Schedule

The planned assembly of the station will begin with launch of the Russian vehicle in November 1997. A docking compartment will be added before the first American launch in December 1997. The Russian service module will be added to the station in January 1998 followed by the universal docking module and the science power platform. The US laboratory module will be launched on the third US flight in 1998 and will signal the beginning of human-tended science operations. The Canadian-built robotic arm will be launched on the next flight in 1998 and the addition of the Soyuz transfer vehicle in August 1998 will provide capabilities for extended on-orbit operations. The Japanese experiment module will be launched in early 2000 and the ESA laboratory module will be added in June 2001. Assembly will be complete in June 2002. In total, the sequence provides for 13 Russian assembly flights and 16 US assembly flights. In addition, up to five flights will be needed each year during construction to supply fuel for raising the station's orbit. Use of the Ariane 5

Joint Statement on Negotiations Related to the Integration of Russia into the Space Station Partnership

Paris - 18 March 1994

Representatives of the governments of the United States, Canada, Japan and the European Partner met for the first time with representatives of the government of the Russian Federation to discuss steps to implement the decision to bring Russia into the partnership. They stressed their interest in Russia joining the International Space Station programme as a full partner as soon as possible. Russian involvement in the International Space Station will help realise the benefits of global partnership and further develop the shared objective of building broad cooperative relationships.

The Russian delegation informed the participants of the key parameters of Russia's planned contribution to the partnership, which will result in a Space Station with enhanced capabilities. The representatives considered the approach to changes to the legal framework of the 1988 agreements on Space Station cooperation that will be needed to include Russia as a Partner, as well as to complete any other necessary adjustments. They also discussed the modalities for negotiating those changes, including a schedule that would allow for early completion of negotiations. The first meeting of the negotiating delegations is planned for April 1994.

The intergovernmental meeting today follows the decision of the Partners in Paris on 16 October 1993, to explore collectively possible Russian partnership, and the Russian acceptance of the formal invitation extended by the partnership as a result of its 6 December 1993 meeting in Washington. The meeting also follows the 7 November 1993 informal meeting in Montreal of Heads of the United States National Aeronautics and Space Administration, the Canadian Space Agency, the National Space Development Agency of Japan, the European Space Agency and the Russian Space Agency covering preliminary technical aspects of Russia's intended participation.

launcher to lift the European module to the station also has been added to the technical baseline.

Cost

The US contribution to the station is estimated to cost $17.4 billion from Fiscal Year 1994 until assembly is complete in 2002. This includes annual budget appropriations of about $2.1 billion and consists of development, vehicle and ground operations costs and utilisation support during the assembly period.

International Partner Status

Canada completed the critical design review for the Space Station remote manipulator system in 1993. Changes in the subsystem design requirement and assembly sequence currently are being addressed.

The critical design review for the Japanese experiment module is scheduled for 1996. Currently all development activities are on track for launch in early 2000. The European attached pressurised module (APM) preliminary design review is scheduled for 1996 with the critical design review scheduled for 1998. Programme managers also are investigating the feasibility of launching the APM on an Ariane 5 booster as a baseline.

The inter-government agreements for the station are currently being amended to include Russia as a full partner. The memorandum of understanding and joint management plan with Russia will be completed in mid-1994 and negotiation of a fixed price contract is currently in hand.

Extravehicular Activities

The amount of extravehicular activity (EVA) in the critical path for station assembly has been significantly reduced. EVA crew hours for maintenance during the station's 10-year operational lifetime have also been significantly reduced.

Ground Control

The ground system for the International Space Station builds on the interfaces for the Shuttle and Freedom programmes. The design is being optimised to reduce developmental and recurring costs. All drivers for the ground control systems are well understood and the final specification will be baselined for May.

Station Systems

All station systems have a high degree of design maturity. For example, the guidance, navigation and control system design is 97 percent complete. The communications and tracking system design is very mature and analysis and testing to date show that all station requirements will be met. The critical design reviews for the audio, video, S-band and Ku-band systems have been completed with more than 90 percent of the flight material on order or available in house.

The thermal control system has been significantly simplified. The external active thermal control system has seen the most significant changes but still retains 40-50 percent of the previous hardware designs. The internal active thermal control system retains 80-90 percent and the photovoltaic active thermal control system retains 100 percent of the existing hardware design.

Analysis shows that designs for the life support systems are also progressing well with development programmes completed for all major subsystems. A number of key environmental system tests have been completed using prototype hardware and 90 percent of the hardware has passed a critical design review.

Transition Activities

Since the transition activities began last autumn, 1,050 open issues from the Freedom programme have been resolved. Another 471 new programme issues also have been closed during that time. At the close of the SDR, only 17 issues remained open which included providing for additional on-orbit payload storage, addressing the noise levels of the Japanese experiment module and the ESA module and determining the location and specifications for an optical quality window in the station design.

With completion of the SDR, the space station team will refine the design to more detailed levels. In April 1995, the critical design review for the station will be conducted, a milestone that means the detailed engineering design will be essentially complete.

According to Wilbur Trafton, "The team is tackling the tough issues, making decisions and moving ahead with a space station that can be built on schedule and at the cost which the Administration and the Congress have established for this programme".

NASA is Over-Stretched

A Congressional Budget Office (CBO) study released on 24 March says that NASA's plans to continue its ambitious space programme despite a shrinking budget are doomed to failure and that the agency should adopt more modest goals, perhaps even grounding the space shuttle fleet or cancelling the proposed space station.

"The attempt to fit a programme that was projected to cost more than $20 billion a year in the late 1990s into an annual budget of $14 billion risks delay, mission failure and the loss of anticipated benefits", the report said.

NASA is facing a reduced annual budget for the first time in 21 years and there will be no increases over the next five years. It has already spent $11.2 billion on space station plans and estimates that the project will cost $17.4 billion more, even with plans to cut costs by establishing a partnership with the Russians. The CBO said NASA's belt-tightening efforts so far are not enough to stay within its reduced budget and offers NASA three options:

(1) Eliminate costly piloted space flight to concentrate on robot spacecraft and to develop new technology for private industry. The cost of this plan would be $7 billion annually.

(2) Emphasize robotic spacecraft and conduct only four space shuttle flights a year, instead of eight. This plan also would cancel the space station, abandon projects aimed at sending piloted missions to the Moon or Mars and leave no room for the joint missions with Russia as now planned. Cost: about $11 billion a year.

(3) Concentrate on piloted space flight, build the space station and plan for eventual manned missions to the Moon and to Mars limiting robot missions to pathfinder projects for the Moon-Mars effort. Cost: about $14.3 billion annually.

This latter plan would severely restrict research in astronomy and physics, including the operation of the Hubble Space Telescope and the Gamma Ray Observatory, which are already in orbit. The Earth Observation System, which would study the environment from orbit, would be hard hit.

Goldin Responds to CBO Report

NASA Administrator Daniel Goldin said the options suggested by the CBO would destroy the agency's essential balance of piloted space flight, science and aeronautics. NASA's budget was already cut to the bone. We cannot accept further budget cuts. Yet we still send men and women to live and work in space. We send spacecraft to explore the heavens. We monitor critical environmental conditions. We are building an international outpost for humans in space and NASA's vibrant aeronautics programme will take American aviation on top in an increasingly competitive global environment.

Any of the three alternatives put forth in the CBO report would destroy this essential balance and would destroy the dream President Kennedy began more than 30 years ago. It also fails to take account of the tremendous termination and transition costs associated with shutting down a major

portion of the space programme, not to mention the potential for enormous economic dislocation.

NASA can accomplish bold, daring and difficult missions on a tight budget. We proved that again with the Hubble rescue mission. We fixed the Hubble on time and under budget, and it is performing beyond our greatest expectations.

Congressional Report Foresees Difficulties

A report, based on a US Congressional Committee tour of the European and Russian space communities and released on 23 March, casts doubts on the feasibility of carrying out the proposed space station project as an international effort in the way currently envisaged by the White House.

The report says that the unexpected signing by the US last December of an agreement (see p.147) to include Russia as a full partner in the project is widely viewed in Europe as only a bilateral 'foreign policy programme of the US' with uncertainty of Russia being taken in as an equal partner in the effort.

America's space station has undergone six redesigns, including one completed in 1993 with another new design announced (see p.149). Based on the experience of the 1993 redesign, Europe has grown increasingly reluctant to tie even mundane scientific projects to US space policy and European confidence in the US-led space station project has reached an all-time low.

The report also expresses doubts about how well the Russians can support their end of the space station project. The Baikonur Cosmodrome is in good condition, but nearby facilities, including the town of Leninsk, are in serious disrepair and a major upgrade and investment in the surrounding infrastructure, including transportation and living facilities, is needed in order to guarantee continued launches from Baikonur.

Shuttle Phase-Out

A recent NASA report entitled *Access to Space* takes a long-term look at ways of meeting the needs of future US space operations. The study was put together by a NASA panel for the White House Office of Science and Technology and, along with assessments by the Department of Defense and the US aerospace industry, could form the basis for future US space policy.

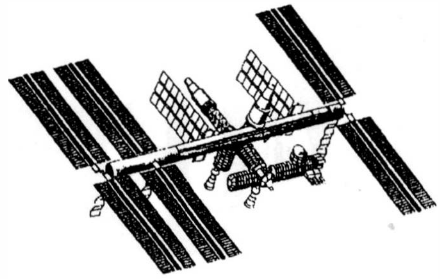
The NASA study concludes that the present fleet of four shuttles should not be perpetuated much beyond the planned assembly of the International Space Station just after the turn of the century. While the fleet could probably remain operational until 2015, the agency rejects upgrading the shuttle for use until 2030 and is now looking for a less costly replacement that would be ready by 2005-2010.

A reusable single-stage launcher made of lightweight materials is proposed which would take off vertically. It would look like a short, chubby version of the Shuttle (without booster rockets and external tank) and would require a smaller launch operations team. The vehicle would be self-guided and could be unmanned for boosting satellites to orbit or equipped with a module for astronauts who would be carried as passengers.

The report also considers the future of the US expendable rocket fleet of Titan, Delta and Atlas launchers and rejects upgrading these in the long-term in favour of the new rocket system in its unmanned mode of operation.

US Aerospace manufacturers have already offered their assessment which is that private industry could provide a new space fleet more quickly and economically than NASA.

The Defense Department is expected to issue its report shortly, following which the White House will be carrying out its review and delivering its recommendations.



Station Assembly Shuttle Flights

Flight	Orbiter	Launch	No.
STS-91	Endeavour	04/12/97	1
STS-93	Discovery	26/02/98	2
STS-95	Endeavour	25/06/98	3
STS-96	Atlantis	30/07/98	4
STS-97	Discovery	24/09/98	5
STS-99	Atlantis	03/12/98	6
STS-100	Discovery	18/02/99	7
STS-102	Atlantis	29/04/99	8
STS-104	Endeavour	29/07/99	9
STS-105	Atlantis	09/09/99	10
STS-107	Endeavour	12/12/99	11
STS-108	Discovery	29/01/00	J1
STS-109	Atlantis	03/02/00	J2
STS-112	Atlantis	20/07/00	J3
STS-115	Atlantis	30/11/00	12
STS-120	Endeavour	14/06/01	E1
STS-122	Discovery	04/10/01	E2
STS-127	Atlantis	09/05/02	13
STS-128	Discovery	18/07/02	14
STS-129	Endeavour	29/08/02	15

In No. column: J - Japan E - Europe

Cosmonaut Questions Space Station Decision

Journalist cosmonaut Valeri Baberdin* has voiced fears, which he claims are shared by many of the cosmonaut corps, that the agreement between the Russian and American governments to create a joint orbital station will lead to the once-mighty Soviet/Russian space infrastructure crumbling to leave the Russians as passengers riding on American shuttles.

Baberdin criticises the Yeltsin government for accepting the American offer of $400 million over the next four years for use of the Mir complex. He says that despite the immediate benefit for Russian space industry, the money will give only a "temporary reprieve" to the cash-starved space programme and will cost the Russians dear in the loss of both their autonomy and experience in space exploration.

Baberdin claims that the US/Russian agreement will "shackle" the Russian side and lead to the subsequent transfer of training and control of the joint station to Houston.

Whereas the Americans have concentrated upon short-duration missions with Space Shuttle orbiters, Russia has maintained quick and relatively cheap access to space through its fleet of carrier rockets, kept cosmonauts in space for long periods of time on the world's only manned space station and developed training procedures for these missions - all things the Americans have not done.

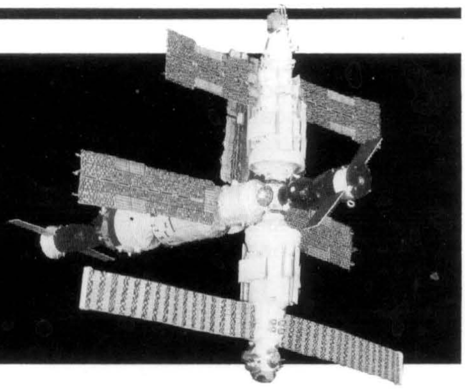
"All these unique technologies and methods will go to the Americans as a free gift together with the part of the new station that we have contracted to build", Baberdin writes. He expects control of the station to be transferred to Houston and missions to it to be mostly flown by the Space Shuttle fleet with Russian and other specialists being ferried to it as "Payload Specialists".

Baberdin also voices the complaint that, whilst foreign cosmonauts take paid places on Soviet and Russian flights, many Russians who have trained for flights remain grounded. Also foreign cosmonauts generally leave their scientific equipment on Mir but take the results of their work back to their own countries on computer disks so that Russians do not have access to the results.

The cosmonaut expressed the fear that the Russians were going down the road of building a joint space station with the Americans and leaving their own great space history behind by "voluntarily following in the wake of foreign interests". NEVILLE KIDGER, FBIS

**Valeri Baberdin is a correspondent for the* Krasnaya Zvedzda *newspaper and has not flown in space.*

MIR MISSION REPORT



Cosmonaut Activities

July 1993 - January 1994

On 14 January 1994 cosmonauts Vasili Tsibilyev and Aleksandr Serebrov were beginning their return to Earth after an extended mission on the Mir complex when a collision between their Soyuz TM-17 spacecraft and the Kristall module, which is a part of the Mir complex, happened as the result of an engine malfunction.

The collision marred the end of an otherwise very successful stay by the 14th main expedition to the Mir station which began on 1 July 1993 with a joint Russian/French mission and had involved five separate EVAs and the unscheduled extension to the flight's duration because of funding difficulties on Earth.

BY NEVILLE KIDGER
Leeds, UK

Drama Mars End of Mission

Soyuz TM-17 had undocked from Mir's front axial docking unit and was being flown by Tsibilyev towards the Kristall module from a distance of 45 metres in order to photograph the APAS docking unit of the Kristall module where the American Space Shuttle Orbiter will dock in 1995. Photographs of the unit in orbit had been requested by the Americans.

But, as Tsibilyev was using the rotational and translational levers to control the small thrusters of the craft, he reported that it was moving slowly and that he was unable to increase the speed of approach by means of the translational control handle as it was stuck in the reserve operating mode. The cause of the malfunction is thought to have been a switch, which is located in the orbital section of the Soyuz, being accidentally knocked to an "off" position.

With Tsibilyev unable to change the attitude of the craft, Soyuz TM-17 caught Kristall a "slight, glancing" blow just 1.5 metres from the docking unit of the module, away from any antennae or scientific equipment. The impact caused the complex's propulsion system and the control gyroscopes to cease operating. They were soon reactivated, however, and checks continued for some days after the collision. On board the complex Viktor Afanasyev and Yuri Usachyev reportedly did not feel the impact.

Progress M-21, which arrived at the end of January, was scheduled to film the impact point before any decision was taken on whether Afanasyev and Usachyev would have to make an unscheduled EVA.

Speaking in early February, Aleksandr Serebrov said that the collision occurred because mission controllers had failed to optimise the manoeuvres required for the late-scheduled photography task. However, an official commission was expected to blame the cosmonauts for the incident.

French Cosmonaut to Mir

The Soyuz TM-17 spacecraft was launched to Mir from the Baikonur Cosmodrome, Kazakhstan, at 14:33 (all times GMT) on 1 July 1993 carrying a three-man crew. The commander was rookie cosmonaut Vasili Tsibilyev. He was accompanied by experienced flight engineer Aleksandr Serebrov and rookie French cosmonaut Jean Pierre Haignére.

After the standard orbital correction manoeuvre during the fourth and fifth orbits, the Soyuz TM-17 craft achieved an orbit of 371 x 227 km and over the following day the cosmonauts continued their pursuit of the orbital complex. The three docking units on the complex were, however, all occupied at the time of the TM-17 launch, Soyuz TM-16 being at the Kristall module's front APAS (Androgynous periphery-type docking assembly) unit and the two Progress cargo ships M-18 and M-17 at the Mir front axial unit and the Kvant astrophysics module respectively. Progress M-18 was therefore undocked from the front axial docking port (at 15:58:16 on 3 July) watched by the Soyuz TM-17 crew who sent back long-range TV pictures. With the docking port cleared Tsibilyev manoeuvred Soyuz TM-17 into an approach trajectory to dock with the front port at 16:24.

(Progress M-18's recoverable ballistic capsule was separated after a re-entry burn on 4 July 1993 and landed at 17:05 near the Russian/ Kazakhstan border.)

French "Altair" Programme

During the French "Altair" programme, the series of medical and technical experiments which had been started one year earlier by French cosmonaut Michel Tognini (see *Spaceflight*, November 1992, p.360) were continued. Since the return of Tognini in August 1992, two experiments (*Nausica* and *Eceq* for studying the radiation of heavy ions and providing dosimetric measurements) had been operating continuously and were now to end with the return of Haignére.

Six additional medical experiments to be conducted were:

Orthostatism, composed of the Echography, Diuresis and Tissue experiments. This test used at Haut Schicht Dicke apparatus which was first used by the German cosmonaut Klaus-Dietrich Flade during his 1992 mission;

Viminal, a miniature flight simulator to study the impact of space factors on adaptation;

Illusions, the adaptation of the human sensor-motor system;

Biodose, the long-term effects of cosmic radiation on humans;

Immunology, the adaptation of the immune system during space missions;

Synergies, a new experiment to study the role of the vestibular system in controlling the dynamic equilibrium and the stabilisation of references in body synergy organisation during complex movements.

There were two technological experiments:

Microaccelerometer a video recorder to measure the microaccelerations on the station;

Teleassistance the qualification

and assessment of the use of a scientific expert on the ground as an experiment is performed in the space complex. The Orthostatism experiment was the subject of the Teleassistance test.

TM-16 Returns

TV pictures of the undocking of the Soyuz TM-16 craft were shown as it pulled away from the Kristall APAS unit. One of the cosmonauts could be seen taking pictures through the window of the "blister" observation port of the living section of the Soyuz.

The Soyuz TM-16 descent capsule landed at 06:42 on 22 July 1993 with cosmonauts Manakov, Poleschuk (after spending 179 days 43 minutes and 45 seconds in space) and Haignére (after 20 days 16 hours 8 minutes and 52 seconds in space).

Experiments In Orbit: Progress M-19 Launched

Tsibilyev and Serebrov were to spend 147 days in space and conduct three EVAs, two of which were designed to assemble the Rapan structure on the outside of the complex. However, there were to be changes as the weeks unfolded.

On 27 July 1993, Tsibilyev and Serebrov conducted experiments with the Buket and Granat telescopes observing the universe at X- and gamma-ray wavelengths. On 10 August 1993, it was reported that they had spent the previous few days studying the interaction of high-energy particles with the Earth's radiation belts.

On 2 August 1993, Mir's ODU (Combined Engine Installation) was refuelled from the tanks of Progress M-17.

Progress M-19 was launched from Baikonur at 22:23:45 on 10 August 1993 into a 243 x 192 km orbit. The spacecraft carried a recoverable ballistic capsule for the return of scientific data. Such capsules can deliver 150 kg of results to Earth. This was to be the sixth one to be used. The other capsules had delivered cargoes of between 106 and 147 kg to Earth with one loss in 1991.

Progress M-17 was undocked from the Kvant port of Mir at 15:36:42 on 11 August 1993 and was eventually put into an orbit some 10 km below the Mir orbit of about 400 km. *Aviation Week and Space Technology* reported that Progress M-17 was to remain in orbit for 1.5 years to study the effects of the space environment upon its systems. Because of the commonality of its systems with those of Soyuz, the condition of Progress after such a long flight should help in understanding the state of a Soyuz docked at the International Space Station for an extended period of time. Soyuz is to be used as the permanently docked Assured Crew Rescue Vehicle (ACRV) on the space station.

Progress M-19 docked with Mir's Kvant port six seconds after midnight on 13 August 1993.

The crew's work continued with astrophysical, technological, geophysical and medical experiments. Two pulsars in the constellations Vela and Centaurus and a variable X-ray source in Circinus were observed. Geophysical observations utilised an Instrument called Flalka-F to study the ultraviolet radiation in near-Earth space. A 220-hr-long smelt was conducted in the Gallar furnace.

Cosmonaut Amateur Radio Team Greets Spaceflight Readers

We are pleased to hear from Sergei Samburov, Space 'MIR' QSL Manager, Chief of the Cosmonaut Amateur Radio Department of NPO Energiya and himself a future cosmonaut. He and fellow cosmonauts, who are licensed Mir radio amateurs, are pleased to be receiving issues of ***Spaceflight***. Seen here in the photograph from the left are: Alex Poleshchuk (R2MIR), Alex Kaleri (U8MIR), Sergei Samburov (RV3DR) and Nikolai Budarin who is one of the group of cosmonauts selected for Mir-Shuttle missions.

Radio amateur activity from Mir began in 1988 and from that time has been the subject of many reports in ***Spaceflight***. See, for example 'Radio Amateur Activity from Space' by J.K. Andersen on page 106 in the March 1993 issue.

Jean Pierre Haignére, who spent three weeks on Mir in July 1993, with Claudie André Deshays, who will be on the next French mission to Mir in 1996. CNES/C. BARDOU

EVA Work Outside Mir

September 1993 was a month when three EVAs took pride of place as the cosmonauts assembled and deployed the Rapan girder outside the complex.

The Rapan truss, which weighs 26 kg and has an extended length of 5 m, is a small-scale version of the truss that was to be used on Mir-2 to support antennae, reflectors and solar gas-turbines. The station is now expected to form part of the International Space Station.

The Rapan truss uses materials which revert to their original shape and can unfold in just three minutes. The work schedule of the two cosmonauts called for them to place it on the Kvant astrophysics module and mount samples of materials on it for exposure to space for a period of 10 months.

EVA-1: The first EVA was conducted on 16 September 1993 when Tsibilyev and Serebrov spent 4 hours and 18 minutes taking Rapan to the Kvant module. They exited the Kvant-2 hatch and used the telescopic jib to move the equipment to the work site. They successfully mounted the folded truss construction on the Kvant equipment platform and linked it electrically to the power systems of the complex, ready for EVA-2 on 20 September 1993.

EVA-2: The men spent 3 hours and 14 minutes outside the complex extending the girder to its full length and they installed samples of materials for exposure on it.

EVA-3: Their third EVA on 28 September 1993 was to film the exterior of the station and the docked modules in order to ascertain the state of the exterior after the Perseid meteor shower in August 1993. One meteor impact had reportedly left a large hole in one of the solar arrays, but a large loss of power was not expected.

Serebrov positioned a new cassette of material samples and collected one of the panels of an American payload called *Trek*. However, Tsibilyev reported feeling too warm and telemetry showed that his EVA suit was overheating. It was assumed that the liquid coolant was not circulating and so, after a shortened EVA of 1 hour and 52 minutes, the men returned to the station.

To complete the tasks of the EVA, the Russian press announced on 8 October 1993 that the next EVA would occur on 22 October 1993.

Change In Plans

Also on 8 October 1993, Radio Moscow announced the postponement of the crew's return to Earth planned for November. Because of a delay in the manufacture of the Soyuz launcher needed to carry their replacement crew into orbit the switch over of crews was postponed until January 4. The factory in Samara, where Soyuz engines are constructed, was reported to be almost bankrupt, owing 14 billion roubles.

The only carrier rocket that would be available for the November launch was the property of the hydrometeorlogical service and could carry just two men into orbit, not the three called for by the flight programme. Therefore, the launch had to be postponed until the correct Soyuz carrier rocket version would be available.

Progress M-20 Launched

Progress M-20 was launched on 11 October 1993 using a Soyuz booster to the type normally used to put Meteor metsats and reconnaissance satellites into orbit. It had been loaned by the Russian Hydrometeorological Committee, according to the Russian military newspaper *Krasnaya Zvezda*. The newspaper reported that a delay of central government funds in reaching the production plant was to blame for the financial situation.

Progress M-20 carried a commercial experiment for the Boeing Corporation who was working in association with NPO Energiya. The small experiment, with 12 specimens, dealt with protein crystal growth and was to operate in space for one month and then be returned to Earth as part of Progress M-20's ballistic capsule payload.

At 17:59 on 12 October 1993, Progress M-19 undocked from the Mir complex and within 7 hours was deorbited, returning its ballistic capsule to Earth where it landed at 00:22 13 October 1993.

At 23:25 13 October 1993 (02:25 MT on 14 October) Progress M-20 docked with the complex at the Kvant port.

More Work Outside: EVA-4

On 22 October 1993 the cosmonauts conducted their fourth EVA, lasting just 38 minutes (reportedly scheduled for 5 hours duration). The excursion made Aleksandr Serebrov the first man in history to conduct nine separate EVAs.

During their EVA the men were addressed by Russian Prime Minister Viktor Chernomyrdin who told them that he had held a meeting with Russian aerospace officials at the Energiya NPO firm that day and the decision had been made to give governmental support to enable the complex to continue working.

The Americans are to pay $400 million over the next 4 years for the use of the Mir complex before they and the Russians embark upon the construction of a joint space station. According to Russian Space Agency chief Yuri Koptev, without US money allocated to the joint space station project, the Russians would not be able to build the Mir-2 part of the station.

On 27 October 1993 Aleksandr Serebrov exchanged greetings with astronauts on the Space Shuttle Orbiter "Columbia" SLS-2 mission (STS-58) via amateur radio.

EVA-5

On 29 October 1993, the cosmonauts emerged again into open space for their fifth (and Serebrov's tenth) EVA. They continued to examine the station's exterior by using the telescopic arm to reach a vantage point from where they could film the solar arrays and also the large radio dish used for communications via a geostationary relay satellite. Routine operations, such as moving over to the Kvant astrophysics module and checking the fastening of the 14-metre-long Sofora support assembly platform were conducted. Before ending their EVA of 4 hours and 12 minutes another cassette of materials, which had been attached to the outer surface of the station for an extended period of time, was retrieved.

The ten EVAs of Aleksandr Serebrov give a total time in open space of 31 hours and 50 minutes, but that is still short of the Russian record of 36 hours and 29 minutes that Sergei Krikalev totalled during his seven EVAs from the Mir complex in 1991-92.

A report later said that the examination of the complex's exterior had revealed that the thermal insulation coating of the station had become sooted up because of exhaust from the small thrusters although it still remained within acceptable limits. The replaceable solar arrays were also in good working order and any repairs that were needed could be carried out by the cosmonauts themselves.

Progress M-20 Departs

At 02:36 on 21 November 1993, Progress M-20 was undocked and deorbited. The recoverable capsule separated and landed in Russia, in the Ural mountains, at 09:03. The capsule brought results of work conducted aboard the complex, including the American biocrystal experiment, samples of materials exposed to space for two years and tiny pieces of the thermal coating from the station's exterior. Although the landing took place on a Sunday, and in extremely cold conditions, the US researchers received their experiment packages in Moscow the same day. The project manager for the Boeing experiment expressed his admiration for the speediness of the Russian response and service.

The rest of the Progress M-20 craft was destroyed as planned on re-entry into the upper atmosphere. TV shots of the burning craft descending through the atmosphere were shown on Russian TV.

Preparations for the Next Launch

The flight postponed until January 1994 was Soyuz TM-18 with Viktor Afanasyev, Yuri Usachyev and Dr Valeri Polyakov as prime crew and the 15th main expedition to Mir. The doctor had already made a 240 day 22 hour and 35 minute flight and plans called for him to stay on Mir for 1.5 years and be returned on the American Shuttle. However the delay in the launch of TM-18 would introduce a corresponding reduction in the time that Dr Polyakov was to spend in space.

A press conference was held on 17 December 1993 to officially introduce the next crew to fly to Mir, which was confirmed as Afanasyev, Usachyev and Dr Polyakov. The launch was set for 8 January and docking for two days later. The resident crew of Tsibilyev and Serebrov would return to Earth after just 4 days of joint work.

The TM-18 reserve crew was confirmed as an all-rookie one - commander Yuri Malenchenko, flight engineer Talgat Musabayev and Dr Gherman Arzamazov. Musabayev became the second Kazakh cosmonaut selected in a flight crew and was the reserve for Tokhtar Aubakirov, the first Kazakh in space in October 1991.

Remarkably, it was revealed later that Dr Arzamazov had been removed from the reserve crew because of what was termed "psychological incompatibility with his colleagues". Arzamazov had reportedly objected to the inclusion of Dr Polyakov in the prime crew, on the grounds that he had not been an active medical practitioner for an extended time, being involved in administrative duties at the Institute of Medical-Biomedical Problems. Dr Arzamazov joined a select band of cosmonauts removed from stand-by duty whilst awaiting a launch.

Over the Christmas and New Year period, as the two crews trained for the TM-18 launch at Baikonur, Tsibilyev and Serebrov in Mir worked with the Optizon furnace, obtaining a semiconductor crystal of silicon, the Kristallizator installation and the Microaccelerometer experiment. They also began regular use of the Chibis pneumatic leggings in preparation for their impending return to Earth.

Soyuz TM-18 Expedition

The flight plan for the 15th main expedition to the Mir station would see cosmonauts Afanasyev, Usachyev and Polyakov continue the medical and scientific work on the station begun by other crews.

The first two cosmonauts would be replaced in late June by cosmonauts Malenchenko and Musabayev, accompanied for the short period of joint work on the station by veteran cosmonaut Gennadi Strekalov, who would return to Earth with Afanasyev and Usachyev. No EVAs were planned at the time of the Soyuz TM-18 launch.

The next manned launch would occur on 3 October 1994. Cosmonauts Aleksandr Viktorenko and Yelena Kondakova (Russia's third female cosmonaut) are to stay on Mir until March 1995. For the first month of their mission they would have the company of Malenchenko and Musabayev as well as German Ulf Merbold, flying for the European Space Agency on the EuroMir-94 project.

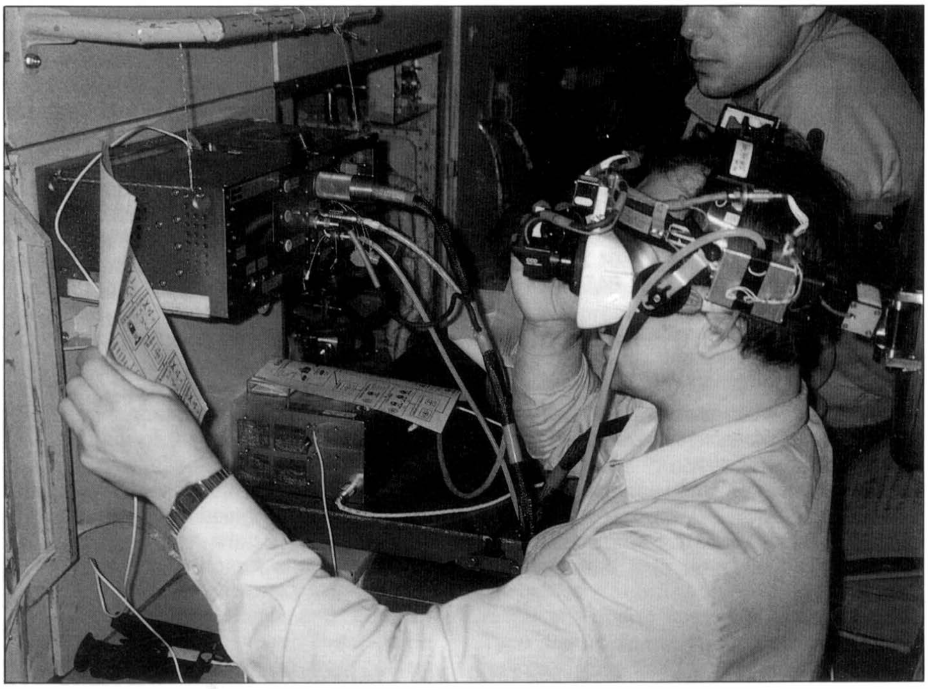
The 1994 flight plan also called for launches of five Progress M missions in January, March, May, July and August to support the manned operations. December should see the much-delayed launch and docking of the *Spektr* module.

Soyuz TM-18 In Flight

Soyuz TM-18 was launched at 10:05:34 on 8 January. The Russian news agency reported that Polyakov was now to spend 427 days in space. Two days later the craft successfully docked with Mir at 11:50. The main research is to be on the adaptation of the human body to microgravity.

TM-17 Returns

At 04:37 on 14 January 1994 Soyuz TM-17 undocked. The cosmonauts then flew the inspection flight around the station which led to the collision with the Kristall module reported above. Soyuz TM-17 landed without further incident at 08:18:20 on the same day some 215 km west of Karaganda in Kazakhstan. ■



Cosmonaut physician Valeri Polyakov during training with the VOG experiment.
KAYSER-THREDE

Real-Time Analysis of Mir Experiment

Arrangements have been made for the performance of the experiment video oculography (VOG) on board Mir to be transmitted in real time to the German ground control centre GSOC in Oberpfaffenhofen. Data are in the form of video images of the eye and for the first time it becomes possible to evaluate these and intervene in the experimental procedure in real time.

The experiment is to be performed over a time span of more than three months by physician Valeri Polyakov.

VOG examines the function of the vestibular organ in the inner ear. Eye movement, that appears when the organ is stimulated, is recorded with a video camera on board the station and analysed by means of digital image interpretation in the laboratory. The method was designed at the Vestibular Research Laboratory of the ENT Clinic of Klinikum Steglitz, FU Berlin (Director: Prof H. Scherer). Kayser-Threde developed, manufactured and tested the facility for space application under contract to DARA. The German experimental hardware was delivered to the Mir station in March 1992 and, after the MIR '92 mission was completed with excellent results, VOG has been developed further for clinical research by the company Sensomotoric Instruments in cooperation with Kayser-Threde.

The instruments, which were planned to be re-used, have been tested and refurbished by Kayser-Threde in 1993 under contract to DARA. Replacement parts and data storage units were delivered to the station in October 1993 by Progress M-20 and Dr Polyakov himself took the last parts along in his personal luggage. KAYSER-THREDE

Russian Manned Space Flights, 1994/95

BY ANNE VAN DEN BERG, The Netherlands

Mission	Mir-crew	Return	Stay-time (days)	Main-crew
TM-18	*Tsibliyev*	14/01/94 - TM17	198	#15
06/01/94	*Serebrov*	14/01/94 - TM17	198	14/01/94
Afanasyev	Afanasyev			Afanasyev
Usachev	Usachev			Usachev
Polyakov	Polyakov			Polyakov
TM-19	*Afanasyev*	04/07/94 - TM18	180	#16
20/06/94	*Usachev*	04/07/94 - TM18	180	04/07/94
Malenchenko	*Polyakov*			Malenchenko
Musabayev	Malenchenko			Musabayev
Strekalov (?)	Musabayev			Polyakov
	Strekalov	04/07/94 - TM18	15	
TM-20	*Malenchenko*	02/11/94 - TM19	136	#17
03/10/94	*Musabayev*	02/11/94 - TM19	136	02/11/94
Viktorenko	*Polyakov*			Viktorenko
Kondakova	Viktorenko			Kondakova
Merbold	Kondakova			Polyakov
	Merbold	02/11/94 - TM19	31	
STS-63				
26/01/95				
US-crew*	Mir fly-by			
Titov				
TM-21	*Viktorenko*	09/03/95 - TM20	160	#18A
01/03/95	*Kondakova*	09/03/95 - TM20	160	09/03/95
Dezhurov	*Polyakov*	09/03/95 - TM20	429	Dezhurov
Strekalov	Dezhurov			Strekalov
Thagard	Strekalov			Thagard
	Thagard			
STS-71	*Dezhurov*	08/06/95 - STS71	97	#18B
30/05/95	*Strekalov*	08/06/95 - STS71	97	08/06/95
US-crew	*Thagard*	08/06/95 - STS71	97	Solovyov
Solovyov	Solovyov			Budarin
Budarin	Budarin			
TM-22	*Solovyov*	25/08/95 - TM21	87	#19
17/08/95	*Budarin*	25/08/95 - TM21	87	25/08/95
Gidzenko	Gidzenko			Gidzenko
Fuglesang	Fuglesang			Fuglesang
Avdeyev	Avdeyev			Avdeyev
STS-74				
26/10/95	Second Shuttle/Mir mission			
TM-23	*Gidzenko*	30/12/95 - TM22	135	#20
22/12/95	*Fuglesang*	30/12/95 - TM22	135	30/12/95
Tsibliyev	*Avdeyev*	30/12/95 - TM22	135	Tsibliyev
Treshev	Tsibliyev			Treshev
	Treshev			

* US crew: James Wetherbee (commander), Eileen Collins (pilot), and mission specialists Michael Foale, Janice Voss and Bernard Harris.

Notes

1. Data are derived from Russian sources.
2. Soyuz TM-19: Gennadi Strekalov was included in the crew on 10 October 1993 because Yuri Malenchenko and Talgat Musabayev (a Kazakh and included for political reasons) are rookies. It is a rule that every Russian space crew has to include an experienced cosmonaut. When Strekalov was included in the TM-21 crew on 5 February 1994 his participation as a TM-19 crewmember was labelled as "possibly".
3. Main crew commanders and pilots are the backups on the previous mission.
4. Early 1993 sources mentioned respectively Duque and Fuglesang as the prime ESA crew members. Merbold and Reiter were announced as primes in a press conference on 31 August 1993 in Zvezdny Gorodok. Merbold and Fuglesang were mentioned in a Russian press article on 2 November 1993.
   Duque and Merbold are training for the Soyuz TM-20 mission; Fuglesang and Reiter for the Soyuz TM-22. Fuglesang and Reiter are to be trained and qualified as flight engineers, not cosmonaut-researchers. An Itar-Tass report of 5 February 1994 mentions Ulf Merbold as the prime crewmember.
5. Soyuz TM-20 is an overlap mission. The Mir station will be occupied by six cosmonauts for a month (from 5 October until 2 November 1994). This is comparable with the mission flown in July 1993, when five cosmonauts lived and worked together in the Mir station for three weeks.
6. Soyuz TM-20: Kondakova will execute the first long-duration flight by a woman. Four female test subjects are now undergoing a six month simulated zero-g bedrest study in support of this mission. Kondakova will also be on board Mir for joint Mir/Shuttle operations (STS-63).
7. Soyuz TM-21: Norman Thagard's backup is Bonnie Dunbar. On 5 February 1994 Itar-Tass reported that the flight and the backup crews for the Soyuz TM-21 expedition were chosen.
8. STS-71 will carry the Mir-18B crew, to include a commander and a flight engineer. Dezhurov, Strekalov, Solovyov and Budarin will have to undergo a short period of Shuttle training in the United States.
9. STS-74: No crew members are mentioned yet.
10. Probably a Canadian astronaut (rumour speaks of Bob Thirsk) will fly a long duration mission on Mir. The first slot is the Soyuz TM-23 mission.
11. The next French spationaut in space will be Claudie André Deshays. She will be launched in 1996.
12. Spektr will be launched on 27 November 1994, the Priroda module on 7 April 1995.

CLASSIFIED ADS

Satellite Network

A $9 billion satellite communications network linking every spot on the globe is planned by William H. Gates, Chairman of Microsoft, and Craig O. McCaw, Chairman of McCaw Cellular Communications with the formation of Teledesic Corporation to build the network and begin service in 2001.

An application was filed on 21 March with the Federal Communications Commission for permission to begin work on the network. At present, the network is little more than a vision as Teledesic has not yet raised the construction and launch money, save for the small fraction Gates and McCaw have contributed. In its FCC application Teledesic is proposing a network that would provide for delivery of services via a global network of 840 satellites in low, 435 mile orbits which would prevent the signal delays common with conventional communications satellites, which operate in geosynchronous orbits.

The network utilises technology based partly on work done in NASA's commercial satellite communications programme and from US defence programmes, including the "Brilliant Pebbles" programme of the Strategic Defense Initiative, which was conceived as an orbiting constellation of 1,000 interconnected satellites. It has also undergone a design audit by NASA's Jet Propulsion Laboratory The programme's $9 billion cost would cover design, construction and deployment. The network represents the first time satellites and their subsystems will be designed and built in large enough quantities to be mass produced and tested, making them more economical. To minimise launch costs, the satellites will be compatible with more than 20 launch systems around the world and will have the ability to be stacked, so that several can be launched at the same time.

McCaw Cellular is the USA's biggest cellular phone company. McCaw is selling it to the American Telephone & Telegraph Co for $12.6 billion. The Microsoft software company is not directly involved, its chairman being involved in a personal capacity.

Hypervelocity Launcher

A hypervelocity launcher at Sandia National Laboratories, Albuquerque has accelerated a quarter-inch-diameter plate of metal to a record-high velocity of 15.8 km/s. This velocity equals the relative velocity of two space objects colliding head-on in low-Earth orbit and is significant because one of the many applications of the Sandia facility is to support NASA in the design of debris shielding for the space station. The launcher allows engineers to reproduce in the laboratory the effect of orbiting space debris colliding with the structure in orbit. The same capability should also now be useful in studying how best to shield future low-Earth-orbit telecommunications satellites from damaging space debris.

Lasers in Space

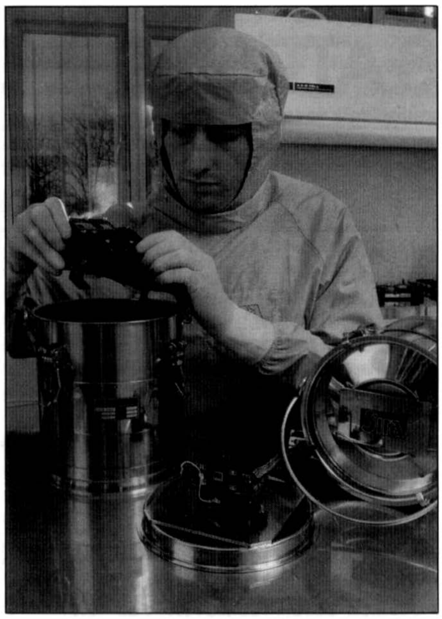
The UK space hardware company, Sira, delivered its first two pairs of SILEX sensors to Matra Marconi Space in March for the first in-flight laser communications in space.

The sensors are destined for the terminal mounted on the low-Earth orbiting satellite SPOT-4 as part of the European Space Agency's SILEX (Semiconductor laser Inter-satellite Link Experiment) project. (See ***Spaceflight***, January 1994, p.35).

Sira is also building space-qualified sensors for the terminal to be mounted on the geostationary ESA technology-demonstration satellite ARTEMIS and the Data Relay Satellite (DRS) to be built for ESA by Alenia Spazio of Italy.

The sensors developed by Sira acquire and track narrow laser beams carrying communications signals between satellites. Laser communications links are attractive because potentially they can handle high data rates with minimal power consumption and high reliability.

Each satellite carries two identical redundant pairs of acquisition and tracking sensors, which are capable of first detecting and then tracking the narrow lasers with an accuracy of better than a microradian as the satellites move through space.



Flight models of Sira's first SILEX data acquisition and tracking sensors, destined for the terminal to be mounted on the ESA satellite SPOT-4. SIRA

The SILEX acquisition and tracking sensors for ARTEMIS and DRS are to be delivered later this year.

ERS Satellites

The European Space Agency (ESA) is considering a proposal to operate both ERS-1 and ERS-2 in orbit simultaneously during 1995. A 'tandem' mission is possible because of the excellent condition of ERS-1, which is now expected to carry on operating until at least the end of 1995. ERS-2 is currently scheduled for launch in December of this year.

Speaking at the Oceanology International conference and exhibition in Brighton in March, Dr David Llwellyn-Jones of the University of Leicester said: "Such a mission would benefit climatology studies, plant growth monitoring and sea ice studies". The tandem mission would dramatically increase the frequency with which data could be obtained from one particular location on the Earth's surface - re-visit intervals are typically 35 days for one spacecraft, but would be just eight days for two satellites.

Dr Llwellyn-Jones also said that using new terrain maps produced by the satellites' ASAR instruments could help hydrologists find solutions to water shortages and rainfall retention in areas of the world prone to drought.

A decision on whether or not to proceed with the tandem mission is likely to be taken by ESA at the end of this year.

SIMPSON COMMUNICATIONS

China and Russia

China and Russia signed a pact on 25 March that paves the way for broad cooperation in virtually all fields of space science, satellite communication, satellite television broadcast and space technology.

Telecom 2 Payloads

Matra Marconi space based in Portsmouth, UK has been awarded a further contract by Alcatel Espace to supply communications equipment for the French national satellite, Telecom 2. This contract follows the delivery of equipment for three previous Telecom 2 satellites, two of which are already operating in orbit.

The Telecom 2 series is operated jointly by the French telecommunication organisation, France Telecom, and the French Ministry of Defence. The equipment supplied by Matra Marconi Space (MMS) is part of the defence communications payload called Syracuse, specifically the X-band beacon transmitter and receiver, which are based on those incorporated in the UK's military communications satellite.

Finland Joins ESA

On 22 March, Mr Matti Vuoria, Secretary General at the Ministry of Trade and Industry, acting on behalf of the Finnish Government, and Mr Jean-Marie Luton, ESA Director General, signed the Agreement for Finland's accession to the ESA Convention, thereby bringing the number of Member States to 14*. Under the Agreement, which will have to be ratified by its Parliament, Finland will become a full ESA Member State on 1 January 1995.

As an associate member of ESA since 1 January 1987, Finland has contributed to its science and optional programmes. It is now planning to participate actively in ESA's space science, Earth observation and satellite communications programmes.

* The thirteen other Member States are: Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom.

SATELLITE DIGEST-264

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Discovery	1994-006A	Feb 3.51	KSC	Shuttle	97,447	Feb 3.54	56.99	91.60	347	359	[1]
ODERACS A	1994-006B				4.25	Feb 14.69	56.99	91.43	333	356	[2]
ODERACS B	1994-006C				4.25	Feb 14.62	56.99	91.45	335	356	
ODERACS C	1994-006D				0.53	No orbital data released					
ODERACS D	1994-006E				0.53	No orbital data released					
ODERACS E	1994-006F				5	Feb 14.82	56.99	91.50	339	357	
ODERACS F	1994-006G				5	Feb 14.63	56.99	91.51	340	357	
BREMSAT	1994-006H				63	Feb 15.71	56.98	91.51	340	357	[3]
Ryusei	1994-007A	Feb 3.93	Tanegashima	H-2	865	Feb 3.92	30.51	93.66	449	459	[4]
Myojo	1994-007B				2,400	Feb 4.26	28.54	642.03	467	36,082	[5]
Raduga-1 3	1994-008A	Feb 5.37	Tyuratam	Proton-4	2,000 ?	Geosynchronous orbit over 49 °E					[6]
Milstar-1 1	1994-009A	Feb 7.91	ER	Titan-4/Centaur	4,670	Geosynchronous orbit					[7]
DFH-3 Model	1994-010A	Feb 8.36	Xi Chang	CZ-3A	2,000 ?	Mar 1.35	28.53	637.69	209	36,118	[8]
Shi Jian 4	1994-010B				400	Mar 1.33	28.53	636.46	210	36,054	[9]
Cosmos 2268	1994-011A	Feb 12.37	Plesetsk	Tsyklon	225 ?	Feb 13.55	82.58	114.20	1,412	1,426	[10]
Cosmos 2269	1994-011B				225 ?	Feb 13.55	82.58	114.13	1,410	1,421	
Cosmos 2270	1994-011C				225 ?	Feb 13.54	82.58	114.04	1,407	1,416	
Cosmos 2271	1994-011D				225 ?	Feb 13.55	82.57	113.99	1,402	1,417	
Cosmos 2272	1994-011E				225 ?	Feb 13.55	82.57	113.91	1,395	1,417	
Cosmos 2273	1994-011F				225 ?	Feb 14.42	82.57	114.05	1,407	1,417	
Raduga 31	1994-012A	Feb 18.33	Tyuratam	Proton-4	2,000 ?	Geosynchronous orbit over 45 °E					[11]
Galaxy-1R #2	1994-013A	Feb 19.99	ER	Delta-2	1,390	Geosynchronous orbit					[12]

NOTES

1. STS-60 mission: C.F. Bolden (commander), K.S. Reightler (pilot), N.J. Davis (mission specialist, MS-1), R.M. Sega (MS-2), F.R. Chang-Diaz (MS-3) and S.K. Krikalyov (MS-4), first Russian to be launched aboard a US spacecraft). Orbiter payload bay carried fixed SPACEHAB-2 (mass 4,287 kg) and Wake Shield Facility (mass 1,683 kg), the latter not deployed in orbit due to a communications problem. Landed KSC February 11.81.
2. ODERACS (Orbital Debris Radar Calibration Spheres) are three pairs of spheres, deployed from the shuttle orbiter 1994 February 9 and flown to permit fine-tuning of Earth-based radar and optical instruments involved in space debris operations.
3. BREMSAT (University of Bremen Satellite) is undertaking research into heat conductivity, microgravity forces, micrometeorite and dust particle distribution, atomic oxygen mapping and re-entry pressures and temperatures. Deployment was shortly after that of the ODERACS payloads.
4. Maiden flight of Japanese H-2 launch vehicle. Ryusei (Shooting Star, called OREX - Orbital Re-entry Experiment - before launch) was flown to gain data on satellite re-entry technology. Splashed down (not recovered) February 4.01.
5. Myojo (Morning Star, called VEP - Vehicle Evaluation Payload - before launch) is a test payload, flown to monitor the H-2 performance and conduct other tests.
6. Third flight of new-generation Raduga satellite, planned to replace older Raduga series.
7. Maiden flight of Titan-4/Centaur launch vehicle carried first Milstar-1 military communications satellite, also called DFS 1 (Development Flight Satellite) and USA 99. No orbital data issued by USSPACECOM.
8. Dummy payload simulating DFH-3 communications satellite, carried aboard maiden flight of CZ-3A. Note - identification by USSPACECOM of the objects from this launch is preliminary.
9. Shi Jian 4 (Practice) is a science payload: carries six experiments including a proton detector, electron detector, potential monitor and single event upset (SEU) monitor.
10. Six second generation military communications satellites.
11. Military communications satellite.
12. Replacement for Galaxy 1R (in turn a replacement for Galaxy 1) communications satellite which was lost in the Atlas 1 launch failure of August 22 1992. Satellite to be located over 227 °E.

ADDITIONS AND UPDATES

1979-091A Molniya-1 45 decayed from orbit 1994 February 18.

1981-096A SBS 2 was manoeuvred off-station over 263 °E approximately 1994 January 23-24.

1982-106A DSCS-2 15 was manoeuvred off-station over 59 °E during January 23-26: from the Two-Line Orbital Elements it was unclear whether the satellite was still drifting at the end of February 1994.

1982-110B SBS 3 was re-located over 285-286 °E at the end of December 1993.

1983-026B TDRS 1 was manoeuvred off-station over 188-189 °E in mid-December 1993: it was re-located over 85-86 °E approximately 1994 February 7 and is now dedicated to data relay from the Compton Gamma Ray Observatory.

1983-058A EUTELSAT-1 F1 was finally re-located over 65-65 °E approximately 1994 January 31.

1984-113B Anik-D 2 has been renamed ARABSAT 1D. The satellite was shown to be operating over 20 °E according to a Two-Line element set dated 1993 December 7, but the next element set to be issued - on 1994 February 4.15 - showed the satellite over 279 °E.

1985-025A INTELSAT 501 was manoeuvred off-station over 173 °E approximately January 19. It was still drifting at the end of February.

1989-041A USSPACECOM has consistently shown DFS 1 to be located over 33-34 °E, although the satellite operator's literature indicated that it was in fact operating over 22-23 °E. A Two-Line element set was issued for January 18.92 showing the satellite over 34 °E and the next element set dated February 1.97 showed the satellite over 23 °E. Rather than being an actual satellite relocation, it is possible that the apparent "shift" was USSPACECOM's correction of the satellite's location.

1989-067A Marcopolo 1 was boosted off-station over 328-329 °E approximately January 7: it was re-located over 5 °E approximately February 17- 20.

1990-015B METEOSAT 5 was manoeuvred off-station over 350 °E approximately January 21-22: it was re-located over 358-359 °E approximately February 7-8.

Baikonur Cosmodrome

Long-Term Use by Russia Awaits Agreement

Russia and Kazakhstan continue to debate the use of the Baikonur Cosmodrome and in December 1993 it was announced that an agreement in principle had been reached for the Russians to rent parts of it from the Kazakhs.

The rents would cover areas in Kazakhstan operated by the Russian Defence Ministry as well as the Russian Space Agency and cover Baikonur and military testing grounds.

Russian Space Agency Head Yuri Koptev said that the RSA would require nowhere near the 4.5 million hectares that the Cosmodrome covers and that the rent would be based upon a newly-defined area. Plans for the RSA to move Proton launchers to Plesetsk in Northern Russia are said to be at least 10 years into the future.

In the Energiya Assembly and Test Building. Nose fairings for Energiya strap-on rockets are stacked on the right.

International Launch Site

Kazakhstan's Government has also proposed making the Cosmodrome part of an international space company run on commercial lines.

The President of Kazakhstan, Nursultan Nazarbayev, left Washington in mid-February after devoting the last two days of his stay in the United States to meetings with American business people. One main Kazakh-American project is the joint use of Baikonur, though particulars of any agreement are not being disclosed. Implementation of the idea, put forward by Nazarbayev last year, of creating an international consortium on the Baikonur base, in which Russia would play far from the leading role, is being hurried through without waiting for an agreement with Moscow on the future for the Cosmodrome.

During the meetings with businessmen, Nazarbayev said that together with Clinton and Warren Christopher he had discussed how to "develop the territory which was earlier called the USSR".

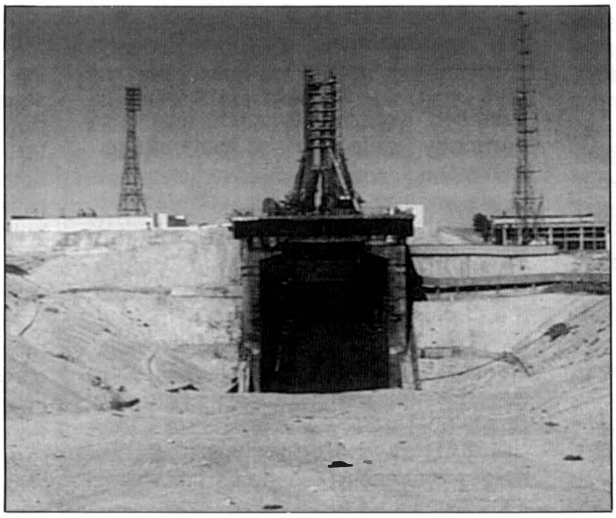
Under consideration are economic projects resulting from meetings with representatives of the American business community. Contracts have been signed to a sum of $5.2 million for oil developments in Kazakhstan by the M-1 Drilling Fluid Company, a protocol on financing by the Minproc Corporation for the building a gold-processing plant and an agreement on joint research at the nuclear testing site in Semipalatinsk.

Great importance is given to an agreement, signed independently of Moscow, on the joint use of Baikonur.

Leaders Discuss Baikonur

Russian president Boris Yeltsin and his counterpart from Kazakhstan, Nursultan Nazarbayev, met in Moscow on 28 March in an effort to negotiate new terms for Russia's use of the Baikonur Cosmodrome and also to strengthen economic, political and military ties. Russia and Kazakhstan have been arguing over Baikonur since 1991. Russia is offering to pay $82.5 million a year for the use of the cosmodrome while Kazakhstan is holding out for $150 million a year. Russia is also asking to lease Baikonur for between 15 and 25 years. Baikonur is the only launch site for Russia's manned space programme.

Based on reports by **NEVILLE KIDGER, FBIS AND ANASTASIA ROMASHKEVICH, RIA NOVOSTI**



Left: **A distant view of the Soyuz launch pad.** Photos: **CHRISTOPHER GAINOR** (*Spaceflight*, February 1993, p.38)

Satellite Digest - 264 - ADDITIONS AND UPDATES *(continued)*

1993-028A	Based upon the orbital regime and the subsequent launch of Cosmos 2267, Cosmos 2243 was possibly the first Russian fifth generation photoreconnaissance satellite to be launched at 70.4°. If this analysis is correct, then the mass of Cosmos 2243 should be "7,000 kg ?".
1993-055	Actual launch date and time were 1993 August 31.19.
1993-056A	No orbital data showing the re-location of UFO 2 were issued during 1993 November 16 - December 16. Data issued on December 16 showed that the satellite had re-located to 71 °E, the November drift rate suggesting that the actual orbital stabilisation might have been approximately November 20.
1993-066A	Orbital data were issued for INTELSAT 701 on 1993 December 21 showing the satellite located over 121 °E: the next orbital data issued was for 1994 January 12, showing the satellite located over 172 °E with a small drift rate.
1993-068A	Add the following orbit for Navstar 23: 1993 November 16.37, 55.07°, 717.99 minutes, 20,105 km, 20,260 km.
1993-071A	Cosmos 2267 is the first Russian fifth generation photoreconnaissance satellite to operate at 70.4°: its mass should be "7,000 kg ?".
1993-073A	Solidaridad 1 has been located over 251 °E.
1993-073B	METEOSAT 6 has been located over 350 °E.
1993-077A	TELSTAR 401 has been located over 270 °E.
1993-078A	DBS 1 has been located over 259 °E.
1993-078B	THAICOM 1 has been located over 78 °E.
1994-002A	Gals 1 has been located over 44 °E.
1994-004A	The acronym DSPSE for Clementine 1 stands for Deep Space Program Science Experiment. The initial mass of the satellite is 458 kg, and the dry mass is 235 kg. Add the following trans-lunar orbital data: 1994 February 3.54, 66.80°, 3,105.53 minutes, 169 km, 128,095 km. Clementine 1 entered selenocentric orbit 1994 February 22.51. The polar orbit (the actual inclination is not available) is 425-2,940 km.

SIR-C Antenna Core Structure (ACS) under test at JPL, Pasadena, USA, 27 October 1992.
© MICHAEL A. CROWE 1994

Space Radar Laboratory

STS-59 is a 9-day mission and carries the International Space Radar Laboratory-1 (SRL-1), consisting of the US Spaceborne Imaging Radar-C (SIR-C) and the joint German/Italian X-band Synthetic Aperture Radar (X-SAR). STS-59 is the first of three dedicated flights of the SRL that are planned to correspond to three different seasons. The next flight (STS-66) is due in August 1994 and the third will probably be in late 1995.

BY MICHAEL A. CROWE
Canberra, Australia

SIR-C/X-SAR

SIR-C/X-SAR is the most massive piece of space hardware ever assembled by NASA's Jet Propulsion Laboratory (JPL). It measures 12 m x 4 m with a weight of 10,500 kg and when mounted on the Spacelab pallet occupies nearly all of the Endeavour payload bay. It represents the next generation of spaceborne imaging radars as it is capable of simultaneously capturing images at multiple frequencies and polarisations. All previous radars flown in space have used only a single frequency. The US project manager, Michael Sander of JPL, suggests one may think of SIR-C/X-SAR as the true equivalent of a colour radar.

SIR-C

SIR-C continues the US development of spaceborne radars that started with SEASAT (1978), followed by SIR-A (1981) and SIR-B (1984). It was built by JPL and the Ball Communications System Division for NASA.

Unlike the single frequency (L-band, 23 cm wavelength) and single polarisation (horizontal) of the three previous radars, SIR-C can operate simultaneously at two frequencies (L-band and C-band, 6 cm wavelength) and will be able to transmit and receive both horizontally (H) and vertically (V) polarised waves. Therefore, SIR-C's two frequencies can each assume four polarised states; two like-polarised - HH, VV and two cross-polarised - HV, VH (the first letter indicates the transmitted polarisation and the second letter indicates the received polarisation, e.g. HV means a horizontally polarised signal is transmitted and a vertically polarised signal is received).

X-SAR

The X-SAR radar, designed and developed by the German Space Agency (DARA) in collaboration with the Italian Space Agency (ASI), follows on from Germany's Microwave Remote Sensing Experiments (MRSE) that was flown on board the Spacelab-1 (STS-9) mission in 1983.

X-SAR is a vertically polarised, single frequency (X-band, 3 cm wavelength) radar that was built by the Dornier and Alenia Spazio companies for DARA and ASI.

> **Science Objectives**
>
> SIR-C/X-SAR will provide images and geophysical measurements of the following:
>
> - vegetation type, extent, and deforestation
> - water storage and flux
> - ocean dynamics, wave fields, and wind fields
> - volcanism and tectonic activity
> - soil erosion and desertification
> - topography

A Single Multi-Polarised, Multi-Frequency Experiment

The capability of SRL-1 to use various combinations of three frequencies and two polarisations allows Earth Science Investigators to conduct numerous experiments.

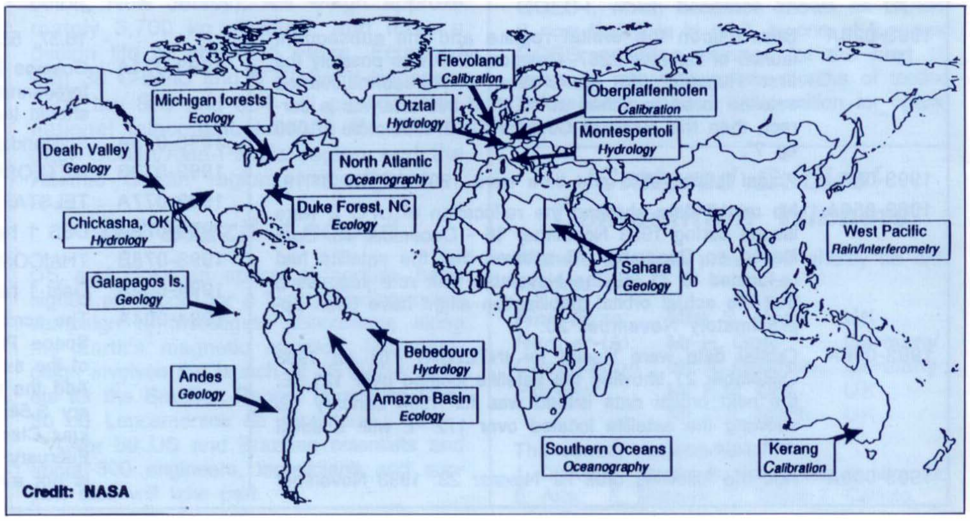
Multiple frequencies may be used, for example, to look at several layers of the foliage of a jungle. The X-band will only penetrate slightly into the upper layer of the jungle canopy. C-band will reach almost half-way, while L-band will get most of the way down. One could therefore assess how much foliage there is by comparing the returns of the three radars.

The polarisation of a radar signal may allow researchers to distinguish the shape of the reflecting medium. A signal bouncing off a cylindrical tree trunk, for example, will be rotated by 90°. The rotation of the signal, then acts like a 'thumb print' of that kind of reflection and would help to distinguish the tree trunk from surrounding soil and water surfaces.

Two Ways to Point a Radar Beam!

SIR-C represents the latest in antenna technology with the use of a distributed phased array of transmitter elements. By properly phasing the transmitted energy from each element the beam can be electronically steered, without actually moving the

SIR-C/X-SAR supersites. Nineteen "supersites" of extreme scientific interest, such as the Amazon Basin and the Sahara Desert, have been identified and will be continually monitored during the mission both from space and with ground measurements at the sites.



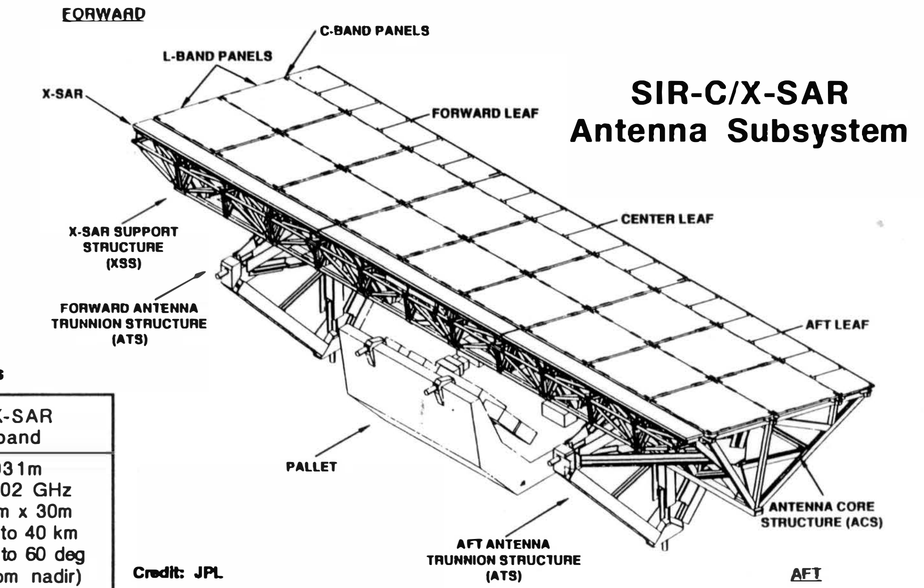
antenna, to view the Earth from angles of incidence that range for 15° to 55°.

X-SAR is built along the 'older' technology lines of SEASAT, SIR-A&B and the European Remote Sensing Satellite (ERS-1) since it uses a slotted waveguide antenna that needs to be physically moved in order to direct the radar beam. On the SRL-1 flight, X-SAR is mounted on a bridge structure that tilts mechanically to align the X-band beam with SIR-C's L-band and C-band beam. It is attached, therefore like a flap, to the edge of the L-band panels of the SIR-C radar antenna.

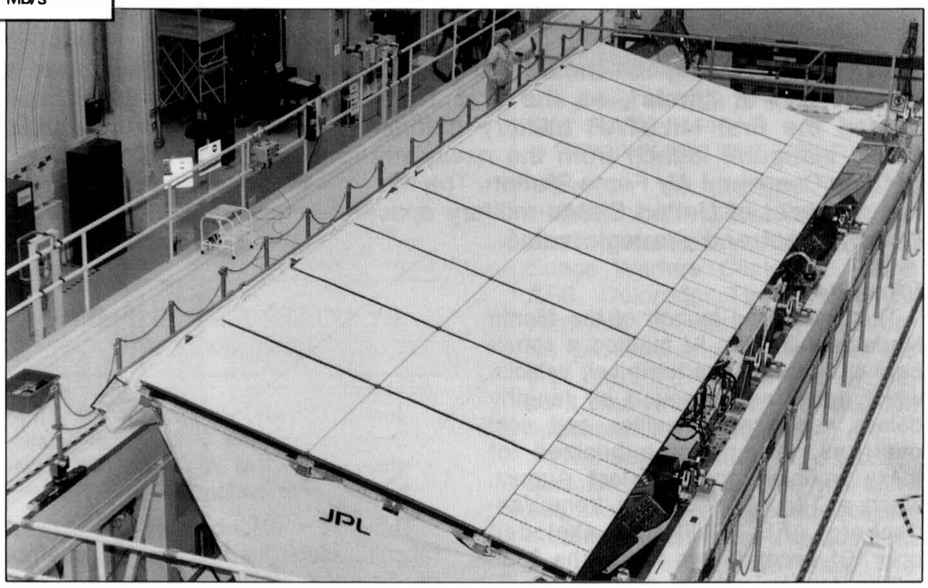
SIR-C/X-SAR System Characteristics

Parameter	SIR-C C-band	SIR-C L-band	X-SAR X-band
Wavelength	0.058m	0.235m	0.031m
Frequency	5289 MHz	1239 MHz	9.602 GHz
Resolution	30m x 30m	30m x 30m	30m x 30m
Swath width	15 to 90 km	15 to 90 km	15 to 40 km
Look angle range	17 to 60 deg (from nadir)	17 to 60 deg (from nadir)	17 to 60 deg (from nadir)
Data	90 Mb/s	90 Mb/s	45 Mb/s

SIR-C/X-SAR Antenna Subsystem



Credit: JPL



STS-59 payload before closeout at the Operations and Checkout Building at KSC.
PETER GUALTIERI, WEST KENTUCKY NEWS

Swath Width and Resolution

SIR-C and X-SAR can operate in conjunction with each other or independently as 'stand alone' radars. The swath widths available therefore vary from 15 km to 90 km, depending on the number of frequencies and polarisations selected as well as the incidence angle. Spatial resolution of the imagery also varies from 10 m to 200 m, depending on the imaging parameters selected.

Data Processing

The five fuel cells on board Endeavour provide the power source for the three radars. It is estimated there is sufficient capacity available to run the radars for a total of 50 hours. 50 million square kilometres of the Earth surface can be imaged generating some 32 terabits of data (32 x 10^{12} bits) at an average data rate of 180 Mbps peaking to 225 Mbps!

All data are stored on board using three next-generation high-density, digital, rotary-head tape recorders (2 operational with 1 as backup). The 50 hours of data are stored on 130 data cartridges (with 30 cartridges as spares).

Portions of the data, mainly X-SAR in real-time, are relayed to the ground via NASA's Tracking and Data Relay Satellite System (TDRSS) 50 Mbps data link. The TDRSS link is only available for about 30% of the time since the orbiter's cargo bay points towards the Earth most of the time, effectively masking the TDRSS satellite.

There are three primary ground data processing sites in Germany, Italy and the US. Germany and Italy are responsible for processing the X-SAR data and JPL in the US for processing the L-band and C-band data. All three then exchange data to ensure that each country has a complete data set. It will take 5 months to produce survey images from the large volume of data generated with more detailed processing expected to take a further nine months.

Spaceborne Radar Development Into the Future

The progressive series of flights of spaceborne radar will enable developers of spaceborne radar to explore different aspects of the phenomena to which radar is sensitive. This has led to a growing appreciation of the capabilities of spaceborne radar. The SRL series of flights, with the highly flexible multi-frequency, multi-polarisation and multi-angle capability, will develop this understanding further by adding more 'richness to the data set'.

The SRL system is the precursor to the Earth Observing System (EOS)-SAR, a polar-orbiting satellite that will form part of NASA's *Mission To Planet Earth*, due to be flown around the year 2002. SRL-1 therefore, will be the first opportunity to establish the optimum wavelengths, polarisations and illumination geometries for the EOS-SAR.

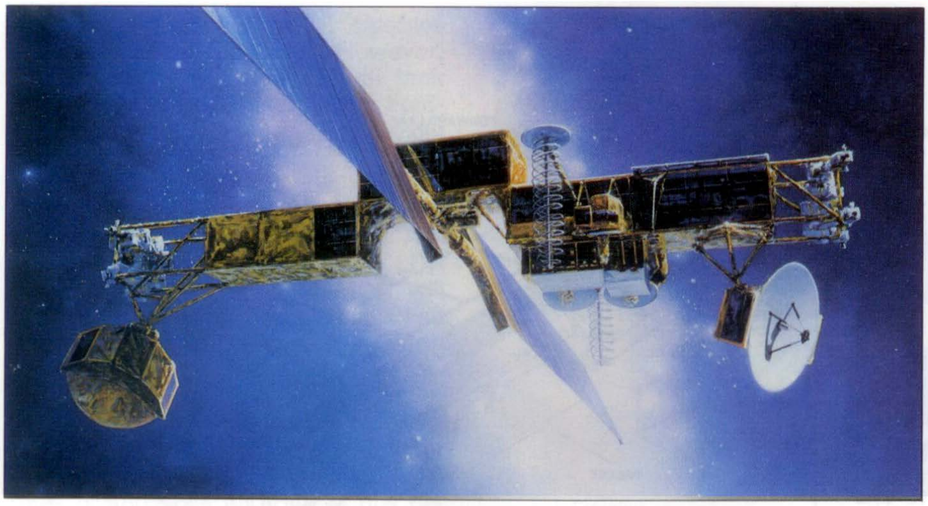
So, while it will undoubtably provide the Earth Sciences community with a wealth of valuable information, the main objective of SRL-1 is to refine the algorithms and software required for the data handling and analysis of data from the future free-flying EOS-SAR platform.

Acknowledgements

The author wishes to acknowledge the assistance of Michael J. Sander, SRL US Project Manager, JPL and Mary A. Hardin, Office of Public Information, JPL.

Sources

1. Interview 27 October 1992, with Michael J. Sander, US Project Manager for SIR-C/S-SAR, at JPL, Pasadena, California.
2. JPL Fact Sheet - 'SIR-C/X-SAR', October 1992.
3. NASA Information Sheet: 'Spaceborne Imaging Radar - C/X-Band Synthetic Aperture Radar (SIR-C/X-SAR)'.
4. NASA Pamphlet: 'Shuttle Imaging Radar - Towards the Future'.
5. W.I. McLaughlin, 'Radar Observation of Earth', Space at JPL, ***Spaceflight***, March 1993, p.102.
6. *Jane's Spaceflight Directory 1993-94*, 9th Edition, 1993.
7. 'SIR-C/X-SAR Readied for April Shuttle Launch', *Space News*, January 17-23, 1994.



Artist's impression of the MILSTAR communications satellite. TRW

First Titan IV/Centaur Launch Puts MILSTAR I into Orbit

On 7 February 1994, the United States Air Force (USAF) accomplished a historic trio of "firsts", as the first Titan IV/Centaur heavy-lift vehicle carried the first MILSTAR military communications satellite into orbit, in the inaugural launch from the newly refurbished Launch Complex 40 at Cape Canaveral Air Force Station. The mission was also one of the most controversial of United States military space efforts, questioned for both its high cost and strategic value.

BY ROGER G. GUILLEMETTE
Rhode Island, USA

Introduction

The successful launch of the Martin Marietta-built Titan IV marked a comeback of sorts for the hard-luck vehicle, which has been plagued by lengthy delays, technical difficulties and cost overruns. The most-publicized of these troubles occurred last August, when a Titan IV launched from Vandenberg AFB, California exploded only 101 seconds into flight. The $330 million launch vehicle was reportedly carrying an $800+ million trio of classified ocean surveillance satellites, making it the second most expensive disaster in US space history (second only to the *Challenger* tragedy).

MILSTAR I is the first of a new generation of advanced military communications satellites intended to be the core command and control system for United States military forces well into the next century. The programme is also one of the most costly, over $17 billion, for the planned constellation of six satellites (not including costs from 1983 to 1992, which remain classified). The United States' most powerful unmanned launch vehicle lifted off at 4:47 pm EST from its oceanside launch complex at Cape Canaveral, blazing a trail of flame and white smoke across a clear blue sky. Visibility was outstanding, and the separation of the Titan IV's twin Solid Rocket Motors was clearly visible to ground observers as the huge rocket arched over the Atlantic Ocean.

Air Force officials were justifiably elated after the successful launch.

"We're back in business," said Colonel Joseph Sovey, director of the Titan Systems Program Office. "This launch gives us back a vital heavy lift capability for the nation."

They were also breathing a sigh of relief. During the first launch attempt on February 5th, the countdown was halted at the T-50 second mark when the PACE (Programmable Aerospace Ground Equipment) computer system detected a problem in the Titan IV's Centaur Upper Stage.

The afternoon of the second launch attempt (February 7th) brought a shift in the winds, worrying Air Force officials enough to evacuate most workers from the industrial area on CCAFS. Fearing that toxic fumes would spread across the area and cause injury in the event of a catastrophic failure, news media personnel were relocated to the roof of the Range Control Center from the original press site, the causeway that separates Cape Canaveral from the Kennedy Space Center.

Seven minutes after launch, the General Dynamics Centaur upper stage ignited on schedule, the first of three firings that boosted the payload toward a geosynchronous orbit. Six-and-a-half hours later, MILSTAR I separated from the Centaur and was placed into its final orbit.

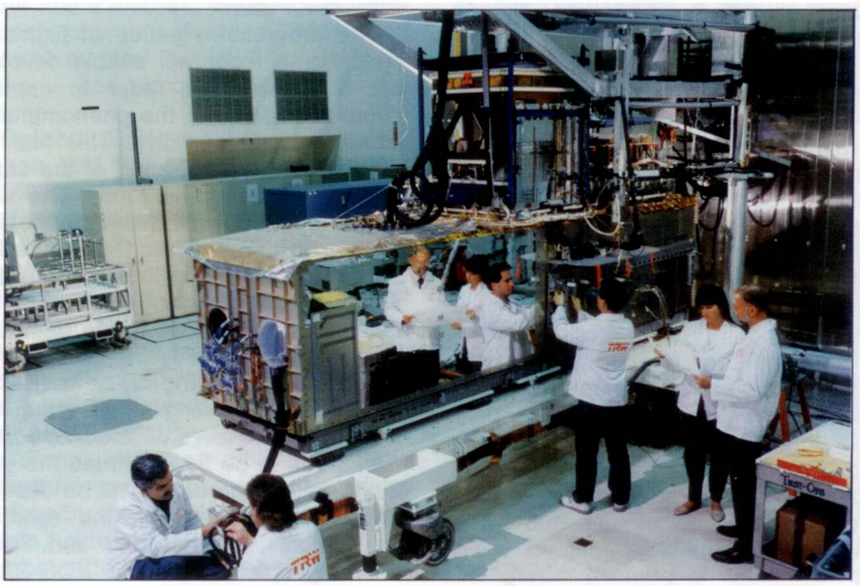
The newest configuration of the high-energy Centaur is a wide-body version specifically designed as an upper stage for the Titan IV. It is 4.25 metres (14 feet) in diameter, increasing its propellant capacity by 50% over the 3 metre (10-foot) diameter Atlas/Centaur model.

"We're back, heavy lift is back, and we're going to keep on doing this for a while," proclaimed USAF Colonel Glenn Waltman, commander of the 45th Operations Group and its 5th Space Launch Squadron, recently formed to support Titan launches.

MILSTAR I Capabilities

The 4500 kilogram (10,000 pound) MILSTAR, for which Lockheed Missile & Space Company is the prime contractor, is a jam-resistant satellite system. It utilizes a revolutionary method of "frequency hopping", that is, rapidly changing transmission frequencies at extremely high frequencies (EHF) designed to foil interception or interference of secured voice, message, and data communications. It is designed to provide "on-demand" access, allowing the satellite to be called "as needed" by users aboard

TRW technicians work on the Low Data Rate payload for MILSTAR satellite. TRW



ships, submarines, aircraft and ground forces.

Operation Desert Storm demonstrated the need for personnel of all three armed services (Army, Navy, Air Force) to be able to communicate with each other over the same network, unimpeded, to coordinate multi-service operations. MILSTAR provides such a common-protocol capability, as well as possessing on-board digital signal processing and supporting direct satellite-to-satellite crosslinks. Crosslinks eliminate the need for the ground relay stations required by all other long-haul comsats that are vulnerable to attack. Instead of ground stations, MILSTAR will permit the use of small, mobile communications terminals that can be moved quickly. On one occasion during the Gulf War, advancing US ground forces were out-of-contact for more than a day while ground stations were relocated.

Originally designed to provide communications during a nuclear conflict, the first two MILSTAR satellites (designated as Block I) are equipped with a Low Data Rate (LDR) EHF communications payload, built by TRW Space & Electronics Group. The LDR payload has 192 channels for data rates of 75 bps to 2400 bps.

The LDR payload will provide high antijamming and nuclear scintillation protection requirements to strategic and tactical users. The strategic users require survivable communications among the National Command Authority and the nuclear capable forces, while the tactical users require survivable communications among forces in different tactical theatres.

The Block I spacecraft are equipped with costly features for nuclear hardness and survivability, enhancements that will not be included in the four Block II satellites. According to Dr. David Klinger, MILSTAR Program manager for Lockheed, this radiation hardening would also protect the satellites from geomagnetic storms (which recently affected the Canadian Anik comsats).

The launch of Titan IV at 4:47 pm EST on 7 February 1994. PETER GUALTIERI, WEST KENTUCKY NEWS

The first Titan IV/Centaur launch vehicle sits poised ready for launch on 7 February 1994. USAF

Centaur upper stage for the Titan IV is tested in the thermal/acoustic test facility, General Dynamics Space Systems Division. GENERAL DYNAMICS

The first MILSTAR i also carries a classified electronics payload that is not operational because, according to USAF, "the mission requirement has been eliminated with the end of the Cold War." The classified package was probably to test a Brilliant Pebbles strategic defence experiment that reportedly involved four vehicles to be launched on a surplus Titan, but was cancelled. The package would have supported testing interactive software on all Brilliant Pebbles testbeds and validate the communications and control links with the Space Warfare Center at Falcon AFB, Colorado. The decision to eliminate the classified electronics package was made after the first MILSTAR I was assembled, so it was retained to maintain the spacecraft's balance.

The second MILSTAR I (scheduled for a 1995 launch) will carry 398 kilograms (878 pounds) of aluminum ballast as a replacement for the classified payload. The substitution of ballast caused quite a controversy in the media, with some news reports claiming that the Air Force was launching 900 kilograms of sand encased in aluminum into orbit, at an estimated cost of some $70 million (based upon Titan IV launch costs of $330 million). The mere mention of the reports of sand ballast visibly irritated MILSTAR program director Brigadier General Leonard F. Kwiatkowski, USAF at a pre-launch press conference. His curt reply, "None of my satellites carry sand!"

General Kwiatkowski announced that the first MILSTAR I would be located over the United States for six months of on-orbit testing and evaluation and, once operational, will be moved to cover the NATO countries, Eastern Europe and the Middle East.

MILSTAR II Enhancements

The next generation MILSTAR II satellites, scheduled for 1999 first launch, will retain the Low Data Rate (LDR) payload developed for the Block I spacecraft, and will be fully interop-

erable with the MILSTAR I satellites for LDR communications. However, the MILSTAR II satellites will lack many of the MILSTAR I's nuclear hardening features to reduce both weight and cost.

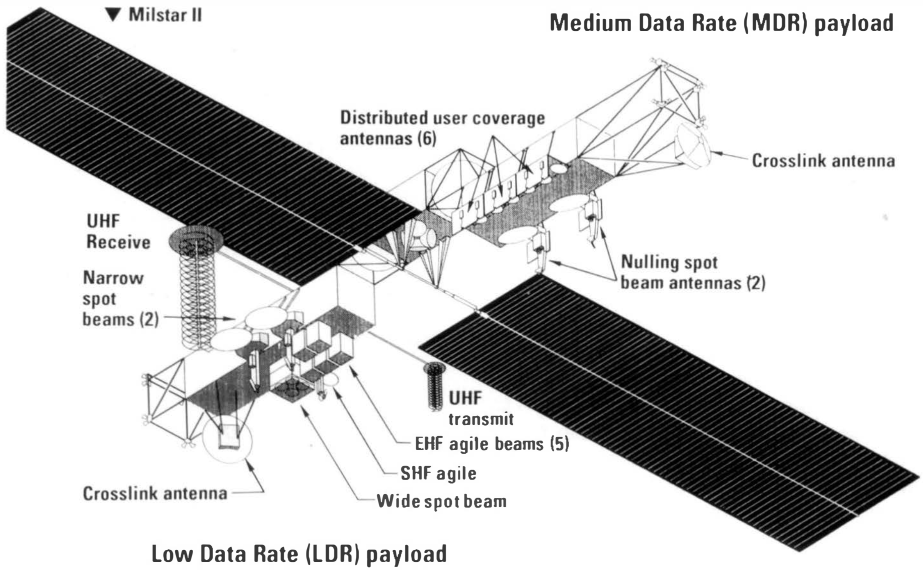
MILSTAR II satellites will add a Medium Data Rate (MDR) payload, under development by Hughes Aircraft Company, in addition to the LDR payload. The MILSTAR II MDR will occupy the space of the classified electronics package that was originally intended for the Block I spacecraft.

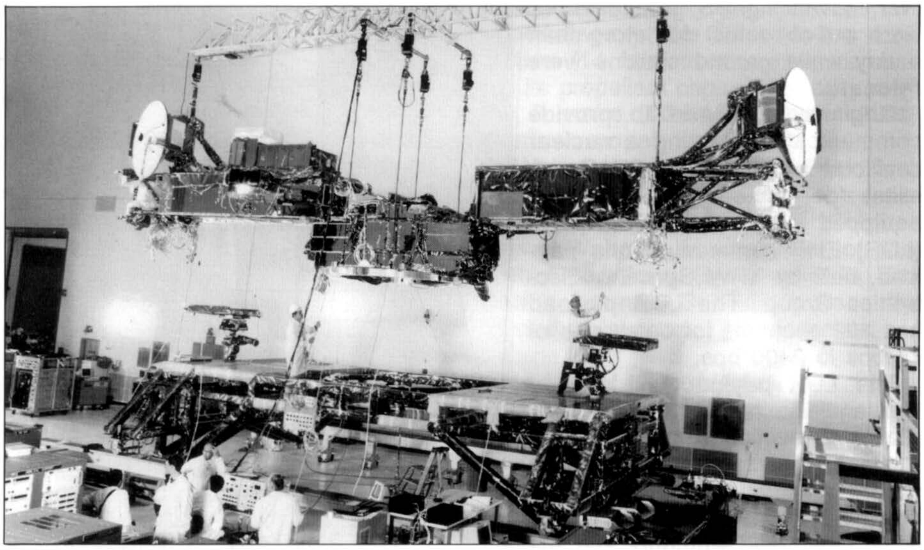
This protected wide bandwidth MDR payload will provide a much higher data rate than the LDR package, with rates of 4800 bps to 1.544 M bps per channel (compared to the very slow 75 to 2400 bps of the LDR). It will permit the transmission of imagery, intelligence and air tasking orders among joint forces, as well as supporting Mobile Subscriber Equipment, the Army's battlefield communications system.

Originally conceived as a nine satellite programme, only four MILSTAR II spacecraft will be built. The last five satellites of the programme will be replaced by an advanced technology EHF spacecraft now in the development stages, labelled the Block III.

The Air Force, under pressure from the Congress to reduce costs, has ordered that the Block III class will be reduced in weight from 4500 kilograms (10,000 pounds) to about 2700 - 3200 kilograms, making the satellites suitable for launch by a medium lift vehicle, instead of the expensive Titan IV heavy lift vehicle.

Total programme costs for the Block I and Block II MILSTAR satellites have been cut back almost $23 billion from the original $40 billion estimate. Projected costs for the Block III spacecraft programme have yet to be determined, but lowering the price tag will be a major objective. As General Kwiatkowski pointed out, "It could be done for a lot less money."





MILSTAR I being prepared by Lockheed technicians for shipment to the Air Force. LOCKHEED

Refurbished Launch Complex 40

The Titan IV Centaur launch was the first flown from Launch Complex 40 (LC-40) after a $335 million facelift. Martin Marietta Astronautics was awarded a contract in January 1990 to rebuild LC-40, and initial launch capability for the Titan IV/Centaur configuration was achieved on 1 March 1993.

The rebuilt LC-40 is now capable of launching all three Titan IV configurations (Centaur, Inertial Upper Stage, No Upper Stage), as well as the smaller Titan III launch vehicles. Its payload fairing airlock system maintains an environment that is cleaner than a hospital operating room.

LC-40's Mobile Service Tower is the largest and heaviest self-propelled structure in the world, weighing 5 million kilograms (11.2 million pounds) and standing 26-stories tall (80 metres). It is designed to withstand hurricane force winds in excess of 160 kilometres/hour (100 mph).

Titan IV Status and Future Plans

Air Force officials, speaking at a prelaunch press conference, addressed recent events in the Titan IV programme and announced plans for the future.

Colonel Sovey expressed confidence that the cause of the August 1993 failure had been identified and that the problem, a burn-through of the Solid Rocket Motor caused by sloppy repair work, had been corrected. He noted that much of the delay in launching Titan IVs, particularly from Cape Canaveral, were caused by setbacks in the Centaur development programme, particularly, difficulties with the Atlas/Centaur variation.

Colonel Waltman noted that the near-term programme goals would be to launch the backlog of heavy payloads, primary Military and Intelligence satellites, that has accrued while the Titan IV fleet has been grounded. He anticipates an annual launch rate into the next century of three to four Titan IVs per year.

Colonel Sovey emphasized the value placed on the Titan IV by the US Defense Department, stating that "every Titan launch is vital to national security." He conveyed the impression that the Air Force feels Titan IV's troubles are now a thing of the past, proclaiming "We are 100% confident ... Titan IV is back!"

Postscript

Nine days after launch, Milstar I's primary power converter failed. Ground controllers at Falcon AFB switched to a backup converter, which routes electricity generated from the solar power arrays into the satellite's systems. According to General Kwiatkowski, the spacecraft, designed to survive and operate in a six-month nuclear war scenario, is still functioning perfectly. He stated that the switch to the backup unit would not reduce the satellite's 10-year life expectancy. ■

STS-59

Endeavour's Environmental Mission

Space Radar Laboratory Maps Selected Sites

Launch of mission STS-59 took place at 7:05 am EDT on 9 April following two days of delay.

The launch was first delayed by one day on 4 April to allow additional inspections of Endeavour's main engines following the discovery of smaller than permitted vanes in the preburner that directs the flow of liquid oxygen through the pump. Then thick clouds and high winds at the launch site on 8 April resulted in a further one-day postponement.

Endeavour's main payload is the International Space Radar Laboratory-1 which is described on pp.160-161 of this issue. In addition to its advanced radar, the Laboratory also includes an air pollution sensor to detect carbon monoxide in the Earth's atmosphere in order to study the effects of industrial pollution and deforestation on the environment.

One of the main assignments of Endeavour's crew (shown on the front cover) is to snap 14,000 photographs with 14 cameras to be coordinated with the radar observations after Endeavour's return from its scheduled nine-day mission.

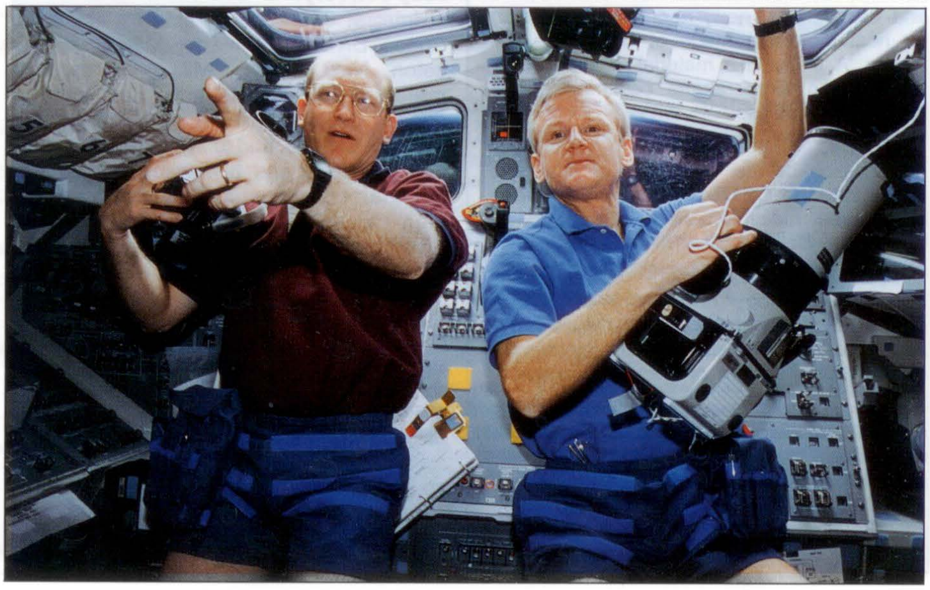
A detailed report of the mission is due to appear in a forthcoming issue of *Spaceflight*.

STS-62 Misses Flight Record by One Hour

Columbia landed on time at the Kennedy Space Center at 8:10 am on 18 March at the end of a 13 day, 23 hour, 17 minute and 35 seconds long mission, the second longest flight in the Space Shuttle Program.

One more orbit would have enabled the crew to have broken the shuttle endurance record, but weather conditions did not cooperate - they were too good for a landing opportunity to be missed with a beautiful, crystal-clear sky.

The mission which began on 4 March featured 11 major science experiments most of which were commanded by remote control from the ground. A detailed account of the mission is due to appear in a forthcoming issue of *Spaceflight*.



With cameras in hand two of the STS-62 astronauts prepare to take pictures of the Earth. John H. Casper (right), mission commander, handles a large format, Linhof camera, while Charles D. (Sam) Gemar, mission specialist, has just added a roll of film to a 70 mm handheld Hasselblad camera. Earth observations and documentation occupied much of the on-duty time of all five of the STS-62 crew members during their 14-day mission in Earth orbit. NASA

First Taurus Launch

New Rocket Orbits Two Satellites

Orbital Sciences Corporation conducted the first Taurus launch on 13 March from Vandenberg Air Force Base, California for the Advanced Research Projects Agency (ARPA) and the US Air Force. The rocket placed two satellites into a precise low-Earth orbit for these agencies. After approximately 10 minutes of ascent, Taurus deployed the DARPASAT and STEP-TAOS satellites into a 290 x 300 nautical mile, 105 degree inclination orbit.

Taurus is designed to provide highly flexible, rapid-response launch capability. The 90-foot tall, 75-ton rocket and all necessary ground support equipment are completely road-transportable and can be readied for launch within eight days from the time of arrival at a minimally-prepared site by a small launch team of approximately 25 people.

Taurus is an inertially-guided, three-axis stabilised solid propellant launch vehicle, capable of boosting up to 3,000 pounds to low-Earth orbit and 950 pounds to geosynchronous transfer orbit. It incorporates advanced structural and avionics technology proven on Pegasus, including the three advanced solid rocket motors developed by Hercules Incorporated which serve as Taurus' second, third and fourth stages. The launch incorporated a Thiokol Corporation Peacekeeper motor as the first stage; however, future launches are expected to use Thiokol's new Castor 120 solid rocket motor.

DARPASAT is a 450-pound, low-cost, classified advanced space technology demonstration satellite. It incorporates a Global Positioning System (GPS) receiver and an on-board data processor designed to validate advanced technologies and the operational utility of direct user tasking and collection of payload data. Built by Ball Aerospace DARPASAT is expected to operate for three years.

The second payload is the 1109 pound Space Test Experiment Platform (STEP) Mission 0 lightsat carrying 10 experiments to investigate technologies that

Checkout of the STEP Mission 0 payload. Ten experiments will investigate ways to make space systems less dependent on ground control. TRW

promise to make space systems less dependent on ground control, thus reducing ground support costs. The experiments will demonstrate such technologies as autonomous satellite navigation, standardised space data bus, advanced radiation hardened processors, and laser and radar sensors. TRW is currently under contract to build four STEP spacecraft with one additional mission under study.

Called Technology for Autonomous Operation Survivability (TAOS), the Mission 0 payload was developed by the Air Force Phillips Laboratory. It is the most complex payload to ride the STEP series, housing seven on-board computers in addition to the raft of experiments.

In 1989, the Air Force sought a standardised lightweight spacecraft that could be economically manufactured in small quantities yet be flexible enough to support widely differing payloads. In 1990, TRW was awarded a contract to design, develop and build the new breed of Air Force small satellites.

Delta Launch of Global Positioning Satellite

On 9 March the 24th Block II NAVSTAR Global Positioning Satellite (GPS) was launched for the US Air Force at Cape Canaveral. The launch completes the NAVSTAR constellation and brings the GPS system to full operational capability.

The Delta II rocket launched the first GPS satellite on 14 February 1989. Four more followed in that year, and another five were added in 1990. Only one satellite was placed in orbit in 1991; however the pace quickened in the next two years, with six launches in both 1992 and 1993.

GPS satellites form a space-based radio navigation system with both military and commercial applications, providing precise position and velocity information to users anywhere in the world.

The rocket carried a secondary payload, the Small Expendable-tether Deployer System (SEDS-2) for NASA. The SEDS project is designed to demonstrate an economical way of delivering smaller payloads, such as micro-satellites, to higher orbits or downward toward the Earth's atmosphere. The first SEDS was launched as a secondary payload aboard a Delta vehicle on 29 March 1993. (See *Spaceflight*, March 1994, p.97 for further SEDS payload details.)

EXPRESS Project

EXPRESS is a joint Russian/German/Japanese project sponsored by DARA, the German Space Agency, which is scheduled for launch on 9 September 1994 with a Japanese M2-S3 rocket.

A Russian reentry capsule is equipped with German infrastructure and German and Japanese experiments.

The German experiments focus on reentry technology and will not therefore be activated before the mission's last phase, i.e. when the capsule enters the atmosphere, deceleration reaches its maximum and temperatures at the stagnation point reach 2,400 °C. The German experiments are as follows:

CETEX, developed by DLR's Stuttgart-based research institute for construction and design, is a new, non-ablative material for heat protection made of C/SiC-fibre ceramics. A tile of this material is exposed to the extreme temperatures occurring during the reentry phase.

PYREX, an experiment of the Institute for Astronautics of the University of Stuttgart, is integrated in CETEX and serves to make contact-free measurement of the temperature at the tile's back.

RAFLEX, the experiment of the Hypersonics Technology Laboratory of Göttingen, is designed to examine the aerodynamic conditions during reentry by means of a complex system of pressure gauges.

Kayser-Threde is responsible for power supplies to the experiments, activation of experiments and aspects of data measurement, storage and handling.

KAYSER-THREDE

(For details of Japan's launch programme before year 2000, see ***Spaceflight***, Oct. 1993, p.344.)

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-65	Early July	Columbia	13 Days	IML-2	28.5
STS-68	August	Endeavour	9 Days	SRL-2	57.0
STS-66	September	Atlantis	10 Days	Atlas-3, Crista-SPAS, SSBUV/A	57.0
STS-64	September	Discovery	9 Days	LITE, GBA	57.0
STS-63	January	Discovery	8 Days	Spacehab-3, Spartan-204, CGP/Oderacs-2	51.6
STS-67	January	Endeavour	13 Days	ASTRO-2	28.5

Professor Rao and Charles Bigot signing the contract for the launch of the INSAT satellites. ARIANESPACE

Two Launches for India

India will put into space two multi-purpose communication satellites made in India in the second-half of 1995 and 1996.

An agreement for the launch of the 2,100 kg satellites, INSAT-2C and 2D, by Arianespace was signed in Bangalore in early March.

The first two satellites, INSAT-2A and 2B, which were launched in 1992 and 1993 respectively from Kourou in French Guiana, are working satisfactorily and have enhanced India's communications, weather forecasting, disaster warning and broadcasting services. The new satellites will provide telecommunications, search and rescue (SAR) as well as educational services for India's domestic needs.

Two More Intelsat VIII

Arianespace and Intelsat have signed a contract for the launch of the Intelsat 803 and 804 satellites. These are the 14th and 15th satellites that the international organisation has entrusted to the Ariane launcher. Launches are scheduled for late 1996 and early 1997, respectively.

Intelsat 803 ad 804, built by the Astro Space Division of Martin Marietta (Princeton, New Jersey), will weigh approximately 3,700 kg at liftoff, and have a design life of about 16 years. Equipped with 38 C-band and 6 Ku-band transponders, the 803 and 804 will provide international telecommunications for the Indian Ocean/Asia-Pacific region and the Atlantic Ocean region, respectively.

US-Brazil Accord

US and Brazilian space authorities have signed an accord for a joint sounding-rocket campaign to investigate phenomena along the Earth's magnetic equator. The campaign involves the launch of 33 NASA rockets for the Brazilian Range, known as Centro de Lancamentos de Alcantara.

Over 50 US and Brazilian scientists and about 300 engineers, technicians and support staff will take part.

Lockheed-Russian Venture

Lockheed Missiles and Space Company announced on 16 March that its joint venture with the Russian space giants, the Khrunichev Space Centre and NPO Energiya, has signed major multi-launch service agreements totalling more than $600 million in business over a five-year span.

Charles Lloyd, president of the joint-venture called Lockheed-Khrunichev-Energiya International (LKEI), said the deals were with America's Loral Corporation and SES, a European direct satellite communication company. The deals entail nine confirmed contracts for launches and options for others with the first scheduled for late 1995 and place LKEI as a strong challenger to the Ariane programme in the $1.6 billion annual commercial satellite launch industry. LKEI plans to use the Russian-built Proton rocket which will incorporate some of the high-tech interface electronics developed by Lockheed. The rockets will be launched from the Baikonur Cosmodrome in Kazakhstan. LKEI will work to identify a comprehensive list of modifications and improvements for the Baikonur facilities, where the proton is launched and has also begun a cooperative dialogue with the insurance underwriting community. The joint LKEI venture was formed in 1993 to enter the world satellite launch market.

New Weather Satellite

On 13 April, GOES-I was successfully launched into geostationary orbit from Cape Canaveral one day after the scheduled launch date and five years later than originally planned. **(See *Spaceflight*, March 1994, p.84).**

The satellite is urgently needed to provide day-to-day forecasting for the US by supporting the work of two aging weather satellites which could fail at any time. GOES-I, which becomes known as GOES-8 now that it is in orbit, is one of five new GOES satellites planned for the next 10 years. It will undergo six months of testing before being moved into position for operational use.

'Cratered Bodies' Competition Winners

Winners to whom prizes will shortly be dispatched are:

First Prize:	Miss S. Heels	UK
Runner-Up:	Mr H. Gust	Germany
Consolation Prizes:	Mr A. Günther	Germany
	Mr H.M. Ord	UK
	Mr C.A. Smith	UK

The correct answers are:
1. Dione; 2. Titania; 3. Ganymede; 4. Miranda; 5. Ariel; 6. Mercury; 7. Triton; 8. Callisto.

Deep into that Darkness Peering

The Case for a 2001 Space Odyssey

Part 1: Outer Solar System Bodies

In a period of only seven months from August 1992 to March 1993, the discovery of two trans-Plutonian objects 1992QB$_1$ and 1993FW advanced the known boundary for planetary-like orbits in the Solar System from 39.5 to no less than 47 au. This size increment almost equals the mean radius of Saturn's orbit. At such distances from the Sun we are out into a region of growing darkness where the strength of sunlight is less than one two-thousandth of that falling on the Earth and the temperature is barely ~30K.

In the six months following the discovery of these two trans-Plutonian objects, four other similar small bodies 1993RO, 1993RP, 1993SB and 1993SC were found orbiting beyond the orbit of Neptune, at heliocentric distances of 32 to 35 au.

Apart from these recently discovered objects, three other curious outer Solar System bodies have been identified since February 1991.

RICHARD L. S. TAYLOR
Probability Research Group,
London, UK

Searching the Dark Frontier

In 1992, sixty-two years after the discovery of Pluto, and in a period of only seven months, the outer limit of the Solar System measured by the most distant object moving in a planetary-like orbit, has been twice thrust outward. The long search astronomers have made of the outer Solar System ever since the discovery of Pluto was at last rewarded. On 30 August 1992, David Jewitt (University of Hawaii) and Jane Luu (University of California at Berkeley) [1] found the object now designated 1992QB$_1$. The exact nature of 1992QB$_1$ is not yet certain, but it is small, about 200 to 240 km in diameter, reddish in colour and it revolves about the Sun at a mean distance of ~44.4 au. Quite remarkably the same team [2] were to repeat their success on 28 March 1993, when they found a second and even more remote object 1993FW orbiting at the distance of ~47 au. Jewitt and Luu believe that 1992QB$_1$ and 1993FW may be the first detected members of the hypothesised Kuiper belt proposed as the source of short period comets.

In the six months following the discovery of 1993FW the idea that the outer Solar System does indeed contain a populated zone composed of ice/rock planetesimal bodies or comets approximating to the hypothesised Kuiper belt received further support when Jewitt and Luu [3,4] in September 1993 discovered two more objects orbiting the Sun at distances of ~32 and ~34 au. Like the orbit of 1992 QB$_1$ the orbits of these two newly discovered objects, 1993RO and 1993RP, have only a low inclination to the ecliptic. Almost simultaneously Iwan Williams (Queen Mary and Westfield College, University of London) and colleagues [5] observing from La Palma in the Canary Islands discovered two more dwarf bodies, 1993SB and 1993SC, orbiting at distances of ~33 and ~34 au respectively. On the basis of their distances and magnitudes all four of these objects seem to be comparable ir. size with 1992QB$_1$ and 1993FW.

However, since 1991 three other small objects have also been discovered and although the mean radii of their orbits are much less than the suggested inner limit of the Kuiper belt, ~35 au, their other characteristics suggest that they themselves could have originated in the trans-Neptunian region of the Solar System. Two of these bodies 1992AD and 1993HA$_2$ occupy orbits with mean radii greater than that of Uranus. The eccentricities of the orbits are relatively large, ~25 and ~50%, greater than that of Chiron, and both reach aphelion beyond the orbit of Neptune. At perihelion 1992AD like Chiron comes within the orbit of Saturn. The third object 1991DA, Damocles, moves in a comet-like orbit that is both very highly inclined and eccentric, (i = 62° e = 0.88). Although the mean orbital radius is only 11.8 au (2.3 au larger than the orbit of Saturn) the perihelion is just inside the orbit of Mars and the aphelion lies beyond Uranus.

There are clearly similarities between the physical nature and orbital dynamics of these three objects and Chiron, but as has been suggested elsewhere [6], Chiron itself shares several important characteristics with a number of other small but widely separated outer Solar System bodies. Taken together these similarities are sufficiently strong to hypothesise that they may have all originated at a far greater heliocentric distance than any of the eight largest planets.

This article attempts to review and assess some of the possible relationships that may exist among the six previously known small ice+rock planetoids and the five more recently discovered outer Solar System bodies. If any of them, now within the realm dominated by the major planets, formed in the remote outer regions of the Solar System they may hold vital information regarding the primordial conditions that existed within the solar nebula. How they came to wander in towards the Sun, is uncertain. Are their inward journeys, and those of comets, just a matter of chance perturbations caused by close passing stars, or are they a consequence of chaotic dynamics in the Solar System? Might a perturbing Planet X perhaps exist after all?

What is clear is that these small bodies, some of which should be near-primordial in composition, almost certainly hold important clues for a fuller and deeper understanding of the origin and evolution of the Solar System as an entity. How are we to find this vital evidence? Much of it could come from a space mission to Pluto.

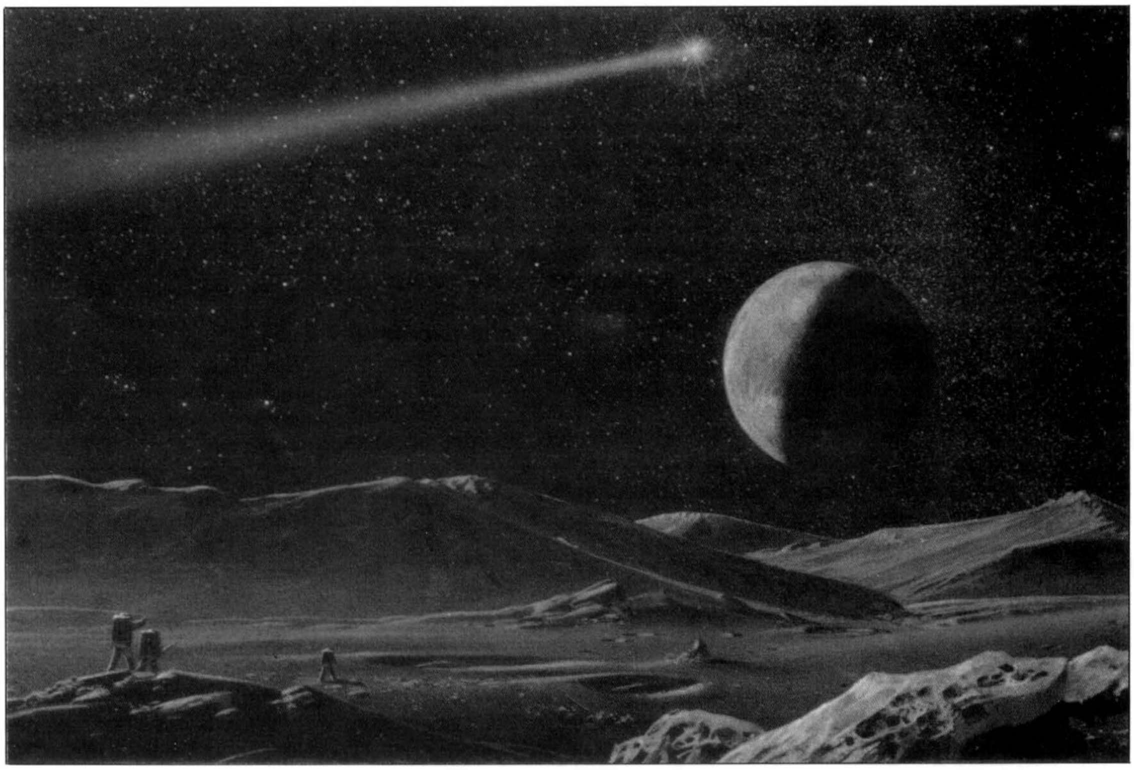
Five Small Objects and a Saturnian Satellite

When Voyager 2 flew by Triton it found a world that was smaller, and less massive than we had believed it to be from terrestrial observations. Seen close up Triton appeared to be similar to Pluto both in size and physical condition. Rather than Pluto being regarded as an escaped satellite of Neptune, it seemed that Triton was itself a small Pluto-like planet that had been captured by Neptune. Voyager

Table I: Principal Characteristics of Chiron, Phoebe and Nereid.

Parameter	Chiron	Phoebe	Nereid
Primary	Sun	Saturn	Neptune
Mean Radius of Orbit	13.69 au	12.95x10^6 km (2)	5.515x10^5 km
Pericentric Distance	8.5 au	10.84x10^6 km	1.379x10^5 km
Apocentric Distance	18.88 au	15.06x10^6 km	9.651x10^5 km
Eccentricity 'e'	0.3786	0.1633 (3)	0.7561
Inclination of Orbit 'i'	6.9°	175.3°	27.5°
Period of Revolution	50.7 yr	R 550.4 d (4)	360.16 d
Period of Rotation	5.9 hr	P 9.4 ± 0.2hr (5)	~13.6 hr (7)
Albedo	~0.08	~0.05	~0.12
Surface Colour	Neutral (1)	Neutral (1)	Neutral (1)
Temperature K	95 - 65	90	50
Mean Radius km	~160(est)	110(est) (6)	~170(est) (8)
Estimated Mass kg (9)	4.3x10^{19} kg	3.5x10^{19} kg	1.2x10^{19} kg

(1) Similar to C-chondrites and C-Type Asteroids.
(2) The next largest orbital radius for a satellite of Saturn is that of Iapetus - mean radius 3.56 x 10^6 km, e = 0.028.
(3) With the exception of Hyperion, e = 0.104, all other Saturnian satellite orbits have eccentricities of <0.029.
(4) R signifies that the orbital motion is retrograde.
(5) P signifies that the rotation is prograde.
(6) 1983 value derived from Voyager 2 encounter data.
(7) Rotation appears to be non-synchronus, see references [30, 31]. Voyager 2 data, reference [29] suggests the period is a few days rather than hours.
(8) 1989 Voyager 2 estimate. Actual diameter may be somewhat larger but <400 km.
(9) These are upper limit estimates based on a chondrite density of ~2000 kg m^{-3}.



Daedalus, the interstellar spacecraft, departs the Solar System on its way to a star. In the foreground is Pluto; in the background is its moon, Charon. ARTIST: RON MILLER

did not approach Nereid, the only other previously known Neptunian satellite, closely and so it was only poorly imaged. Just as the orbit of Triton is unusual in having retrograde motion, the orbit of Nereid is peculiar in possessing the highest eccentricity known for any satellite orbit ~0.75. The discovery of six additional small satellites, moving in small-radius circular orbits close to the equatorial plane of Neptune, suggested that Nereid is also a captured object. Triton and Nereid are not the only small bodies whose origin and natures are strangely ambiguous. The unusual nature of a number of them began to emerge with two important discoveries of the late 1970's and the Voyager 2 1981 encounter with Saturn.

Before discussing the two trans-Plutonian objects and the other three small outer Solar System bodies discovered since 1991 we will look at the similarities that appear to exist among the six previously known small bodies. Their main characteristics are shown in Table I for objects of radius <500 km, and in Table II for those of radius >500 km.

Chiron: The mean radius of Chiron's orbit is about five times that of the main asteroid belt. The orbit is inclined 6.9° to the plane of the Solar System, about the same angle as the orbit of Mercury, and has an eccentricity $e = 0.3786$. Because of this large eccentricity Chiron travels from about 1 au inside the orbit of Saturn at perihelion out to a distance only ~0.3 au less than that of Uranus. On the assumption that Chiron's surface albedo was typical of main-belt asteroids, first estimates of its visual magnitude suggest a radius ~150 km.

Computer studies of Chiron's orbit reveal it to be chaotic [7,8,9] so it is impossible to 'replay' its past motion for more than $\sim 10^5$ years. However, in that brief time Chiron has come close to, and passed right through, Saturn's satellite system. In 1664 BC Chiron passed Saturn at a distance of less than 0.1 au, about the same distance as Saturn's outermost moon, Phoebe, orbits the planet. Such close encounters can perturb the satellite orbits and greatly affect the orbit of Chiron decreasing or increasing its eccentricity and mean radius. Because of such encounters the orbit is changing continually. By AD 7400 it is calculated that the inclination will have increased from 6.9° to 9° and the period will have shortened from 51 to less than 46 years. Other calculations suggest that there is an 80% probability that Chiron will be perturbed into the inner Solar System within $\sim 10^4$ years.

At the time of discovery Chiron was only 6.5 years passed aphelion and near its lowest temperature. The temperature increases slowly as Chiron moves towards its next perihelion passage in 1996. Over the years immediately following discovery, observation revealed a number of inconsistencies in magnitude measurements made at different times by different observers. Measurements taken one year apart [10,11] gave a change in brightness of almost one magnitude. This was unexpected for by 1981 Chiron was known to have a flat greyish neutral spectrum very similar to a C-Type asteroid and quite unlike that of bright icy materials.

These seemingly random fluctuations in brightness continued to be observed. A periodic variation was ruled out as the changes would have had to be directly related to Chiron's period of rotation. A very small periodic variation in brightness of 0.09 magnitude matching a rotation period of 5.9 hr was found in a CCD light curve but then no evidence was found of any large non-periodic variation [12].

Random brightening by a magnitude or more hinted at a possibility of comet-like behaviour as gaseous outbursts could create a large and reflective coma. In 1988 David Tholen [13] used the NASA IRT (Infrared Telescope) in Hawaii to observe Chiron over three nights to see if there was any evidence to support the idea of a comet-like behaviour. Although he found Chiron to be 0.7 magnitude brighter than predicted four years earlier no coma was detectable and the spectrum failed to show any comet-like emission features. However, throughout the 1980's there was a trend for Chiron to brighten, and by late 1988 it was ~1 magnitude brighter than the expected value. Behaviour that might be expected of a comet approaching perihelion, but observation still failed to find any trace of a coma.

It fell to Karen Meech (University of Hawaii) and Michael Belton (Kitt Peak National Observatory) first to discover a coma around Chiron [14]. In April 1989 they were observing Chiron with the 4 metre aperture telescope at KPNO when they detected a coma that appeared to be composed of dust and CO_2 escaping from the surface. They succeeded in confirming their observation the following night, and only a little later, working with the University of Hawaii 2.24 metre telescope on Mauna Kea, Jane Luu and David Jewitt were able to produce false colour images in red light showing a coma. The coma was elongated away from the Sun and appeared to be made up of CO and dust grains. It was foreshortened by the angle of view but extended over some 10

arc seconds corresponding to ~80000 km at the observation distance of 1.5 x 10^9 km. The actual length of the coma was calculated to be > 2 x 10^6 km. These observations reveal comet-like behaviour but can an object as large as Chiron be regarded as a true comet?

Pluto and Charon: In the 1970's interest in Pluto increased as it approached the first perihelion passage since discovery. Then relatively little was known about Pluto. In 1976 methane ice had been detected on the surface of the planet [15], but the first really important advance came in July 1978 when James Christy of the US Naval Observatory [16] announced that Pluto had a satellite. This quite unexpected discovery meant that the mass of the planet could at last be determined, and the perturbations in the motion of Uranus and Neptune attributable to Pluto could be accurately computed. Any residuals might then be due to the hypothesised existence of a trans-Plutonian Planet X.

To account for the supposed perturbations of Neptune, the mass of Pluto was estimated in the 1970's to be 60 to 80% of the mass of the Earth. This large mass was impossible to reconcile with the bolometric estimates of the diameter of Pluto without accepting an improbably high density for the planet (~50000 kg m^{-3}). By the late 1970's the idea that the Pluto was massive enough to cause any significant perturbations in the motions of Neptune or Uranus had been largely abandoned. The likely mass was revised downward to ~0.1 $M_{(Earth)}$ roughly equivalent to the mass of Mars.

The discovery of Pluto's satellite [17] revealed the mass of the Pluto system is exceedingly small 1.48 x 10^{22} kg, that is about ~0.0023 $M_{(Earth)}$. Both physically and dynamically the Pluto-satellite system is unique. The satellite is unusually large, about ~50% of the primary diameter, and it is in synchronous orbit. The period of the satellite's revolution is exactly the same as Pluto's period of rotation - 6.387 days. The obliquity of the planet's rotational axis is found to be ~122.5° so that like Uranus the rotation is retrograde. This obliquity varies between 102° and 126° over a period of ~4 x 10^6 years or so. At the high end of this range the climatic effects arising from the high orbital eccentricity are exaggerated even further. These facts, [18,19] and the highly fortuitous luck of discovering the satellite just before the Earth passed through the orbital plane of Pluto meant that 1985 through 1989 astronomers have been able to observe a series of mutual eclipse cycles as planet and satellite alternately passed in front of each other. These eclipses made it possible to determine the respective diameters of the two bodies more accurately and have given us entirely new information regarding variations in surface composition, brightness and colour for each body.

In 1980 it became clear that a tenuous atmosphere that appeared to consist of methane was developing around Pluto [20]. The planet passed through perihelion on 5 September 1989, but thermal-lag will result in the mass of the atmosphere continuing to increase for some time after perihelion. In May 1992, an international team of astronomers led by Tobias Owen [21] (University of Hawaii) using the UKIRT (United Kingdom Infra-Red Telescope) in Hawaii detected weak absorptions of N_2 and CO ice on the surface. As the estimated day-time temperature then was >50K and both N_2 and CO sublime more readily than methane the implication is that the atmosphere is composed chiefly of nitrogen and carbon monoxide with just a trace of methane, an atmospheric composition similar to that of Triton. The observed evaporation and out-gassing phenomenon raise the question, is much of the 'atmosphere' released at each perihelion passage lost or recondensed upon Pluto's surface? If the atmosphere is escaping at a significant rate, Pluto's solar wind interaction will resemble that of a comet and this should be observable over the next few years.

Spectroscopically Pluto and Charon differ in a number of ways. The Charon spectrum shows little or no trace of an atmosphere but indicates a covering of water frost [22] on a neutral grey surface. Pluto is more highly reflective and is reddish in colour. The general appearance suggests a covering of frozen methane and other ices that may be re-condensed from the atmosphere as the planet moves away from perihelion. Pluto has bright polar caps and a greyish equatorial belt marked with a number of darker spots [23,24,25] and is probably very similar to Neptune's satellite Triton in general appearance. Charon's surface shows relatively small albedo variations and Charon appears to be much like Chiron, although considerably larger.

Phoebe - Outermost Satellite of Saturn: In 1981 Voyager 2 passed through Saturn's extensive satellite system but Phoebe, the most distant of Saturn's satellites, was only poorly imaged as Voyager came no closer than ~1.5 x 10^6 km and most data was gathered [26,27] from more than 2.2 x 10^6 km away. Because of the distance of the encounter the images obtained were only 11 pixels across so there are no large scale pictures of the surface of Phoebe. Nevertheless, contrast features with brightness variations of ~50% were detected and although the resolution of the Voyager images does not allow the unambiguous identification of topographic features the existence of prominent surface contrast features may indicate the presence of impact craters of ≥ 22 km diameter. However, it has to be noted that given the phase angle and resolution of the Voyager 2 images even craters ~100 km across would only be marginally visible. The Voyager data also revealed that Phoebe, which follows a highly eccentric retrograde orbit, has a non-synchronous prograde rotation of 9.4 ± 0.2hr. The surface colour and brightness showed it to be quite unlike any of the other saturnian satellites. In many respects Phoebe looks like a captured C-Type asteroid, but more detailed examination of this dark neutral coloured body makes it appear to be a surprisingly close cousin of Chiron.

Triton: Until the late 1970's Triton [28] was believed to be one of the largest satellites in the Solar System, it was estimated to be ~85% more massive than the Moon and have a radius similar to that of Ganymede, (2640 km), Jupiter's largest satellite. An atmosphere of methane and nitrogen had been detected around Triton and it was conjectured that there might be oceans of liquid nitrogen on the surface. Before the Voyager encounter more precise ground based observations had led to a substantial reduction in the estimated radius for Triton. Even so the estimate remained large, 1750 ± 250 km, and even after adjusting the expected density of Triton downwards to that of Titan, (~2100 kg m^{-3}) the expected mass was 0.42 to 1.0 $M_{(Moon)}$.

Voyager [29] found Triton to have an

Table II: Principal Characteristics of Charon, Pluto and Triton.

Parameter	Charon	Pluto	Triton
Primary	Pluto	Sun	Neptune
Mean Radius of Orbit	19600 km(1)	39.53 au	3.543x10^5 km
Pericentric Distance	-	29.73 au	3.541x10^5 km
Apocentric Distance	-	49.33 au	3.545x10^5 km
Eccentricity 'e'	~0.00	0.248	0.0005
Inclination of Orbit 'i'	94.3±1.5°	17.2°	157.0°
Period of Revolution	6.387 d	247.7 yr	R 5.88 d(4)
Period of Rotation	6.387 d	R 6.387 d(4)	R 5.88 d(4)
Albedo	~0.20	~0.50	~0.70
Surface Colour	Neutral(2)	Reddish(5)	Reddish(5)
Surface Materials	H_2O ice	$N_2/CO/CH_4/H_2O$ ices	N_2/CH_4 ices
Atmosphere	-	N_2 + CO + CH_4(trace)	N_2 + CH_4(trace)
Temperature K	58 - 35	58 - 30	38
Mean Radius km	~593(est)	~1142(est)(6)	~1360(est)(7)
Estimated Mass kg(3)	1.12x10^{21} kg	1.23x10^{22} kg	2.258x10^{22} kg
Estimated Density kg m-3	1510	2330	2100

(1) Synchronous radius: error on this determination is ± 2%. The barycentre is ~2$R_{(Pluto)}$ from the centre of the planet.
(2) Similar to C-chondrites and C-Type asteroids.
(3) Derived masses represent upper bounds derived from terrestrial and Voyager 2 data.
(4) R signifies that the orbital motion is retrograde.
(5) Coloration may be due to tholin hydrocarbon contaminants derived from CH_4.
(6) 1988 value derived from photometric data gives upper bound.
(7) 1989 Voyager 2 encounter data.

averaged albedo of ~0.70, almost twice the terrestrial based estimate, and at the poles the albedo reached values approaching ~0.9. This high reflectivity had led to an over estimate of the radius when measured from Earth and the 1360 km Voyager measurement is 140 km less than the minimum estimate made from the best terrestrial observations. The mass of Triton also proved to be small, less than one-third of the mass of the Moon, not quite twice the mass of Pluto.

The atmosphere, which some astronomers had estimated to have a surface pressure of as much as ~0.1 bar [28], is extremely tenuous. The surface pressure is only ~15 μbar, about 1/70000 of the atmospheric pressure on Earth. The atmosphere is composed almost entirely of nitrogen, the methane content amounts to only 0.01%. Temperature is unbelievably low, ~37 K, so there are no liquid nitrogen seas. Only an icy uncratered world showing signs of a once highly active geology, perhaps the result of the stress of capture. A world with traces of continuing weak activity in the form of at least two nitrogen powered geysers gushing up to ~8 km above the surface.

The surface [28] seems to be made up of different ices contaminated in substantial areas by small quantities of photochemically produced organics that give those parts of the surface a reddish colour. Structurally Triton appears to be made up of two layers of volatile materials and a rocky core of radius ~1035 km. The core accounts for ~0.44 of the volume and ~0.68 of the mass. In terms of composition and structure, and in its possession of bright polar caps, Triton seems to be a slightly larger and on average slightly warmer version of Pluto.

Nereid: The best Voyager image of Nereid was taken from a distance of 4.7 x 10^6 km so the resolution is only about 60% of the low resolution images of Phoebe. The spectrum shows the surface to be a dark neutral colour with contrast variations that were no greater than those detected on Phoebe. Nereid has a radius of 170 km and may be nearly spherical. Ground based photometry Schaefer and Schaefer (1988) reported brightness variations of more than 1.5 magnitudes [30] suggesting that Nereid might be rotating with a period of between 8 and 24 hours. Williams et al [31] observed a variation in brightness of 1.3 magnitudes and determined a rotation period of 13.6 hr. Observations [29] over a period of 12 days by Voyager 2 showed no evidence of a variation of light-curve amplitude greater than 0.1 magnitude indicating that Nereid is either is almost spherical or rotates only very slowly. Given the extreme eccentricity (e = ~0.75) of Nereid's orbit the rotation of the satellite is expected to be non-synchronous. As in the case of the planet Mercury, over time the rotation of Nereid would be expected to evolve towards a strong high-order resonant state with a spin period of circa 50 days. A non-synchronus rotational period of hours to a few days could be regarded as supporting evidence for origin by capture. Dobrovolskis and Scargle [32] have examined the possible rotational evolution of Nereid and shown that the satellite is likely to be in chaotic rotation for any spin period longer than ~14 days. The spectrum of Nereid [29] closely resembles that of Chiron, perhaps with a trace of water hoar frost on its surface. These characteristics along with the highly inclined (i = 27.5°) and eccentric orbit - the orbital velocity of Nereid at pericentre is a mere 200 m s^{-1} below escape velocity - suggest strongly that like Triton, Nereid is a captured object.

Post 1991 Discoveries and the Trans-Plutonian Objects

1991DA Damocles: 18 February 1991, Robert McNaught [33], discovered a very small asteroidal object ~5 km in diameter in a remarkable orbit with a mean radius of 11.8 au and a period of 41 years. Temporarily called 1991DA the object comes to perihelion inside the orbit of Mars but goes out to an aphelion at 22.2 au, well beyond Uranus, and 3 au more distant than the aphelion of Chiron. The eccentricity and the inclination (e = 0.88, i = 62°) of the orbit of 1991DA are more typical of a comet than an asteroid but high magnification images made with CCD detectors on the Australian National University 1 metre telescope showed no sign of a coma. A spectrogram made in red light with the 3.9 metre AAT (Anglo-Australian Telescope) also failed to reveal any sign of cometary emissions. Observations made with the 1.5 metre Danish telescope at La Silla did detect a rapid variation in brightness of about 0.5 magnitude over a period of only 40 minutes probably indicating rapid rotation. The colour appears to be neutral grey.

1992AD Pholus: Found by David Rabinowitz when he spotted it on CCD images taken on the Spacewatch telescope at Kitt Peak, the asteroid was near its perihelion of 8.7 au when discovered. The mean radius of the orbit is greater than that of Uranus and its period is 93 years. The orbital eccentricity of 0.57 takes 1992AD [34] out to an aphelion that lies more than 2 au beyond Neptune. The orbit is much more like that of Chiron than that of 1991DA, but it is almost four times more steeply inclined to the ecliptic, i = 25°, and some 8° more than the orbit of Pluto. Assuming an average albedo for a neutral coloured object 1992AD appears to be about 150 km in diameter, however, photoelectric measurements made by David Tholen suggest that 1992AD may be redder than any asteroid previously observed and the diameter may have been rather underestimated.

$1992QB_1$: If we define the outer limit of the solar system by the most remote object known that revolves about the Sun in an orbit of planetary nature then on 30 August 1992, the mean radius of the outer limit of the Solar System was increased from 39.5 to 44.4 au. When David Jewitt and Jane Luu [1] discovered $1992QB_1$ it turned out to be a very faint, magnitude ~23, reddish colour object with a diameter of 200 to 240 km. $1992QB_1$ moves in an orbit that is truly planetary in nature, the eccentricity and inclination of the orbit are low and characteristic of the major planetary orbits rather than that of Pluto. At e = 0.11 the eccentricity is only 20% greater than that of the orbit of Mars and the inclination i = 2.2° is virtually the same as the orbit of Saturn. Although the mean radius of the orbit of $1992QB_1$ is almost 5 au greater than that of Pluto's orbit, and the period of 296 years is longer, the lower orbital eccentricity means that the aphelion distance of the $1992QB_1$ is not as far from the Sun as that of Pluto. Similarly the perihelion distance is only ~0.07 au greater than the mean radius of Pluto's orbit. Thus in some sense if $1992QB_1$ is to be regarded as a candidate Kuiper belt object then it is possible to regard Pluto and Charon also as at least ex-officio candidates for membership.

1993FW: The gap between the discovery of $1992QB_1$ and that of the second trans-Plutonian object 1993FW was only seven months. The discovery was made in March 1993, by David Jewitt and Jane Luu [2] and was announced in IAU Circular 5370. Object 1993FW appears to be a close twin of $1992QB_1$ in that the size, diameter ~200 km, and spectral appearance are closely similar. Much the same can be said for the characteristics of its orbit that has a mean radius of ~47 au and

Table III: The Characteristics of Five of the Recently Discovered Small Outer Solar System Objects and Chiron Compared.

Characteristic	1991DA Damocles	1992AD Pholus	1993HA2	$1992QB_1$ 'Smiley'	1993FW 'Karla'	Chiron
Discovered:						
Year/month	1991/02	1992/01	1993/04	1992/08	1993/03	1977/11
Diameter km:(1)	5	150 - 200	~100	200 - 240	~200	250 - 320
Colour:	neutral	v. red	neutral	reddish	reddish	neutral
Orbit:						
Mean Radius	~11.8 au	20.35 au	~24.87 au	44.4au	~47 au	13.69 au
Perihelion	~1.5 au	8.7 au	~11.9 au	39.6 au	~38 au	8.5 au
Aphelion	~22.2 au	32 au	~37.8 au	49.1 au	~56 au	18.88 au
Eccentricity 'e'	0.88	0.57	0.52	0.11	0.19	0.38
Inclination 'i' °	62°	25°	15.57°	2.2°	~7.9°	6.9°
Period - years	~41	93	124	296	~322	50.7

(1) Upper and lower diameter limits determined from reflectance spectra and apparent magnitude.

Table IV: The Characteristics of the Six 'Kuiper Belt' Objects Compared.

Characteristic	1993RO	1993 SB	1993SC	1993RP	$1992QB_1$ 'Smiley'	1993FW 'Karla'
Discovery:						
year/month	1993/9	1993/9	1993/9	1993/9	1992/08	1993/03
Distance	~32 au	33.15 au	34.45 au	~35 au	39.998 au	42.145 au
Size/Colour						
Diameter km:(1)	~200	~180	~180	~180	200 -240	~200
Colour:	reddish?	reddish?	reddish?	reddish?	reddish	reddish
Orbit:						
Mean Radius	32.32	33.07	34.38	35.37	44.4au	~47 au
Perihelion					39.6 au	~38 au
Aphelion					49.1 au	~56 au
Eccentricity 'e'	0.01	0.002	0.002	0.01	0.11	0.19
Inclination 'i' °	2.53°	2.13°	5.58°	2.79°	2.213°	7.745°
Period - years	185.77	190.25	201.57	210.4	296	~322

(1) Upper and lower diameter limits determined from reflectance spectra and apparent magnitude.

perihelion and aphelion distances of ~38 and ~56 au respectively. The eccentricity of the orbit is greater than that of $1992QB_1$, and although not equalling the eccentricity of the orbit of Pluto it is only a little less than that of Mercury. The value of 'i' is low, 7.9°, and as in the case of $1992QB_1$ the orbit of this second trans-Plutonian planetoid straddles the orbit of Pluto. At perihelion it comes about 1.5 au inside Pluto's mean distance but at aphelion it almost 7 au further from the Sun than the greatest distance reached by Pluto. The period of ~322 years is also the longest known for an object moving in a planetary style orbit.

$1993HA_2$: Discovered by Dave Rabinowitz [35] of the University of Arizona at Tucson, $1993HA_2$ is a close twin of 1992AD in terms of its main characteristics in much the same way as $1992QB_1$ and 1993FW seem to be 'twins'. The diameter of $1993HA_2$ is ~100 km and at 24.87 au the mean radius of its orbit is some ~4.5 au greater than that of 1992AD. The orbit inclined at ~15.6° and is less eccentric with the value of e = 0.52 falling between the eccentricities of the orbits of Chiron and 1992AD. At aphelion $1993HA_2$ recedes to 37.8 au from the Sun, nearly 8 au beyond Neptune. Taking ~124 years to complete its orbit, at its closest to the Sun, 11.9 au, $1993HA_2$ is about 2.4 au more distant than either Chiron or 1992AD and its mean temperature can be expected to be lower. The similarity of 1992AD, $1993HA_2$ and Chiron is such that the name originally proposed for the hoped-for belt of Chiron class objects, 'Centaurs', can usefully be applied to this trio.

The 'September' Dwarfs - 1993RO, 1993RP, 1993SB and 1993SC: The time elapsed between the discovery of 1993FW and the identification of a further pair of trans-Neptunian dwarf bodies by Jewitt and Luu [3,4] in September 1993 was less than six months. Remarkable as this was in itself, two further trans-neptunian dwarf objects were found by Iwan Williams et al, [5] from La Palma in the Canaries on the 22nd of the same month. The visual brightness of these four objects ranged from 22nd to 24th magnitude and their spectra appear similar to those of $1992QB_1$ and 1993FW. As these 'September' dwarfs are closer to the Sun than $1992QB_1$ and 1993FW it appears that they are of comparable size with diameters probably in the range 150 to 250 km. Three of these newly discovered dwarfs move in orbits with inclinations of ~2.5° virtually the same as that of the orbit of $1992QB_1$, the orbit of the fourth object 1993SC is inclined more steeply at ~5.6° making it more like 1993FW, i = ~7.75° in this respect. Current observational data appears to indicate that all four orbits are of low eccentricity. The perihelion position angles of 1993RO and 1993RP are both close to 180° and those of 1993SB and 1993SC, which orbit the Sun between the orbits of 1993RO and 1993RP, are both close to 3.5°. So 1993SB and 1993SC reach perihelion almost exactly on the opposite side of the Sun from 1993RO and 1993RP. The orbit of Pluto overlaps all four orbits which may be regarded as defining the inner-most edge of the Kuiper Belt.

The known characteristics of $1993HA_2$, the other outer Solar System bodies and the trans-Plutonian objects discovered since the 1991 are shown in Table III and those of the trans-Neptune and trans-Pluto dwarfs in Table IV.

References

1. D. Jewitt and J. Luu, 'Discovery of the candidate Kuiper belt object 1992 QB_1', *Nature*, **362**, 730-732, (1993).
2. D. Jewitt and J. Luu, '1993FW' *IAU Circ.* No. 5730, (1993).
3. D. Jewitt and J. Luu, *IAU Circ.* No. 5865; (1993).
4. D. Jewitt and J. Luu, *IAU Circ.* No. 5867; (1993).
5. I.P. Williams, *IAU Circ.* No. 5869; (1993).
6. R.L.S.Taylor, 'Plomets from Afar', *Space*, 7, 37-42, (1991).
7. C.T. Kowal, Chiron, In *Asteroids* ed, T. Gehrels (Univ. of Arizona Press, Tucson), 436-439, (1979).
8. C.T. Kowal, W. Liller and B.G. Marsden, In Dynamics of the Solar System, *IAU Symp. No.81* ed. R.L. Duncombe, (D. Reidel, Dordrecht), 245-250, (1979).
9. S. Oikawa and E. Everhart, The past and future orbit of 1977UB, object Chiron; *Astron.J.*, **84**, 134-139, (1979).
10. L.A. Lebofsky, D.J. Tholen, G.H. Rieke and M.J. Lebofsky; 2060 Chiron: Visual and thermal Infrared observations; *Icarus*, **60**, 532-537, (1984).
11. S.J. Bus, E. Bowell and L.M. French, 2060 Chiron, *IAU Circ.* No. 4684; (1988).
12. S.J. Bus, E. Bowell, A.W. Harris and A.V. Hewitt, 2060 Chiron: CCD and electronographic photometry; *Icarus*, **77**, 223-238, (1989).
13. D.J. Tholen, W.K. Hartmann & D.P. Cruikshank, '2060 Chiron' *IAU Circ.* No. 4554, (1988).
14. News Notes, *Sky & Telescope*, **78**, 14, (1989).
15. D.P. Cruikshank, C.B. Pilcher and D. Morrison, Pluto: evidence for methane frost; *Science*, **194**, 835-837, (1976).
16. J.W. Christy and R.J. Harrington, The satellite of Pluto; *Astron. J.*, **83**, 1005-1008, (1978).
17. R.J. Harrington and J.W. Christy, The satellite of Pluto III; *Astron. J.*, **86**, 442-443, (1981).
18. J.D. Mulholland and R.P. Binzel, Eclipse Phenomena in the Pluto-Charon System; *Astron. J.*, **89**, 882-888, (1984).
19. R.P. Binzel, D.J. Tholen, E.F. Tedesco, B.J. Buratti, and R.M. Nelson, The detection of eclipses in the Pluto-Charon System; *Science*, **228**, 1193-1195, (1985).
20. U. Fink, B.A. Smith, D.C. Benner, J.R. Johnson, H.J. Reitsema and J.A. Westphal, Detection of a CH4 Atmosphere on Pluto; *Icarus*, **44**, 62-71, (1980).
21. Astronomy Express announcement, *Sky & Telescope*, **84**, 392, 1992.
22. R.L. Marcialis, G.H. Rieke and L.A. Lebofsky, The surface composition of Charon: Tentative Identification of water ice; *Science*, **237**, 1349-1351, (1987).
23. R.L. Marcialis, A two spot model for the surface of Pluto; *Astron. J.*, **95**, 941-977, (1988).
24. M. Littmann, 'Planets Beyond', John Wiley & Sons, New York; pp.180-185, (1988).
25. R.A. Kerr, Geophysicists Take a Tour Around the Solar System: report of the May 1992 Montreal meeting of the American Geophysical Union; *Science*, **256**, 1634-1635, (1992).
26. P. Thomas, J. Veverka, D. Morrison, M. Davies, T.V. Johnson and B.A. Smith, Phoebe: Voyager 2 observations; *J. Geophys. Res.* **88**, 8736-8742, (1983).
27. D. Morrison, T. Owen and L. A. Soderblom, In *Satellites* ed. J.A. Burns and M.S. Matthews, (Univ. of Arizona Press, Tucson); p.784, (1986).
28. D.P. Cruikshank and R.H. Brown, In *Satellites* ed. J.A. Burns and M.S. Matthews, (Univ. of Arizona Press, Tucson); pp.848-856, (1986).
29. B.A. Smith *et al.* Voyager 2 at Neptune: Imaging science results; *Science*, **246**, 1422-1449, (1989).
30. M.W. Schaefer and B.E. Schaefer, Large amplitude photometric variations of Nereid; *Nature*, **333**, 436-438, (1988).
31. I.P. Williams, D.H.P. Jones and D.B. Taylor, The rotation period of Nereid, *Mon. Not. Roy. Astron. Soc.* **250**, 1-2, (1991).
32. A.R. Dobrovolskis and J. D. Scargle, Abstract - Chaotic Rotation of Nereid?; Presented at the Neptune and Triton Conference, Tuson, Arizona, U.S.A. Jan. 6-10, (1992).
33. R. McNaught and D. Steel; *Minor Planet Circ.* No. 20878, (1992).
34. J.V. Scottie; '1992AD', IAU Circ. No.5434, (1992).
35. Science News; *New Scientist*, **138**, 16, (1993).

The Global Jukebox - an estimated 1.3 billion people tuned into the "Live Aid" concerts of July 1985 thanks to the use of satellite technology. INTELSAT

"Shooting Rubber Bands at the Stars"

The Exploration of Space As Reflected In Pop And Rock Music

At times its all too easy to become wrapped up in the technical details of the conquest of space. To do so, however, is to overlook the fact that few technological achievements - with the possible exception of the invention of the atomic bomb - have had such a profound impact on the collective mind of the human race. Looking at the wider picture, it is apparent that the 'space age' is not merely just an achievement of science and technology, but a sociological phenomenon, which as such has influenced many areas of contemporary arts, including literature, cinema and music.

DARREN L. BURNHAM
Oxford, UK

Threshold of a Dream

It is often said that if you want to know what's going on in a society, take a look at its popular culture. Few art forms are more deeply rooted in the present than pop and rock music, and as if to prove this axiom, few art forms have been more inspired by the conquest of space than rock and pop music. The fact that this is so should not come as any great surprise. Both the 'space age' and 'Rock-n'-Roll' came into being at much the same time, and significantly, pop music is predominantly (though increasingly less so) the music of youth, the very section of society upon which the space age has had the greatest impact. Both, in their own ways, also became powerful symbols of the cold war.

As the many letters published in ***Spaceflight*** in response to Mark Hempsell's article on Tasmin Archer's No. 1 single, *"Sleeping Satellite"*, have shown, there is certainly no lack of interest in the subject of 'space music' [1,2]. This article is not intended to be the definitive statement on the subject, but it does provide the opportunity to take a more detailed look at some of the varying ways by which pop and rock musicians have attempted to reflect the achievements of the space age. In so doing it looks at songs which are fairly representative of the various approaches used, although in most cases these do not necessarily equate to the best known songs or the most successful hits.

In striving to prepare such a study, one immediately faces the problem of how to define what actually constitutes 'space music'. The association between music and space is not by any means a new phenomenon. A large number of classical works were inspired by celestial themes, with Gustav Holst's *"Planet's Suite"* perhaps being the best known example. In more recent times, during the '40s and '50s, standards such as *"Swinging On A Star"* alluded to mankind's age old dream of exploring the heavens without showing any grasp as to how this might actually be accomplished.

While compositions of the pre rock and roll era are not without merit and have played their part in the overall history of 'space music', they have been ignored for the purposes of this article which restricts itself to contemporary music recorded since 1957. Also, at the risk of antagonising the French Government, the main thrust of the discussion is unashamedly Anglo-American in its outlook.

A further problem exists in the overlapping boundaries between the worlds of science fact and science fiction, and popular notions of UFO's and 'Close Encounters'. The hues of the spectrum vary from Jeff Wayne's *"War Of The Worlds"*, an ambitious musical interpretation of H.G. Wells' novel, to the comic book heroics of Elton John's *"Dan Dare"*. An even greater number of songs, such as The Byrds *"Mr Spaceman"*, provide colourful accounts of trips to Earth by Extra-Terrestrial tourists. As entertaining as such songs are, they are not discussed here, and the study is restricted to songs which at least give the appearance of having been influenced by actual events of the space age.

Even when those works which have been inspired by science fiction have been discarded, the parentage of what remains can often be called into question. Any attempts at classification are

Susan Helms, keyboard player for astronaut band 'Max Q', practises her skills while floating about on Endeavour's middeck during mission STS-54. NASA

bound to failure, but for convenience this article attempts to identify three main sub-groups which can be characterised thus: 'The Good', ie those songs which take a positive view of space travel, 'The Bad', which are manifestly critical, and 'The Indifferent', those songs which merely use space themes as a flag of convenience in the quest to create a catchy tune. Inevitability, there are many fuzzy boundaries where such arbitrary definitions break down.

Have guitar, will travel into space - two decades after the release of 'The Ventures in Space' the veteran guitar heroes recorded the 'NASA 25th Anniversary Commemorative Album'. THE OFFICIAL VENTURES INTERNATIONAL CLUB

Money for Nothing
- The Indifferent

The willingness of pop and rock musicians to draw upon space themes is as old as rock itself. The rock era unofficially began in 1955 with the release of *"Rock Around The Clock"*, a song which was performed by none other than Bill Haley and his Comets. Other acts soon followed in the footsteps of The Comets, including The Moontrekkers, The Skatalites and The Spotnicks. As the space programme matured and the scientists and engineers created their own impenetrable vocabulary, so the list of bands willing to plagiarise space themes grew longer, as shown by the emergence of Spacemen 3, Sigue Sigue Sputnik, Six Finger Satellite, and Cosmonauts Hail Satan to name but a few. The trend has been pluralistic, and no brand of music has been able to fully resist the influence of the space age.

"Satellite Fever" naturally took hold with the launch of Sputnik 1 in October 1957 and several records referred to Sputnik in their title's.

Space events of the '60s were dominated by the all persuasive influence of the Moon race. Ebbing and flowing in this intellectual tide was Jonathan King's *"Everyone's Gone To The Moon"*, which found success on both sides of the Atlantic in 1965. This rather whimsical song unknowingly helped bridge the gap between the old standards such as *"Swinging On A Star"* and the more ambitious journeys which would come in the near future.

The second half of the decade saw the emergence of 'progressive' and 'underground' rock, and a profusion of space songs abounded in the psychedelic efflorescence. Exponents varied from established names such as The Rolling Stones, who surrendered their well tried and tested 'R n' B' formula in favour of the greater experimentation represented by their *"2000 Light Years From Home"*; to doyens of the burgeoning counter-culture on the verge of making a mainstream breakthrough. Foremost among these were Pink Floyd, whose live repertoire included *"Point Me At The Sky And Let It Fly"*, in addition to other better known compositions which appeared on their studio albums [3]. Since many of these artists worked on the principle of free association it is difficult to know how much emphasis to place on the perceived relationship to space. Certainly the high's and long journey's to which such pieces referred were not anything like those that the real astronauts experienced, for most of these songs were heavily influenced by the drug culture of the late 1960s. Still, to paraphrase an old saying, in space nobody can hear you inhaling!

By the time *"Walking On The Moon"* became a number one hit for The Police in December 1979, the Moon race of the sixties had become part of distant history. Aided and abetted by a video which featured the trio larking about the Kennedy Space Center, the song is now affectionately remembered as one of the more famous space songs, but that was not always the case. The history of the song dates back to an evening that Sting - the band's lead vocalist and principal song-writer - spent in a Hamburg disco. Sting returned to his hotel room and began singing the line "walking around the room", thus establishing the song's central riff. Only in the cold light of day was the title changed to the far more catchy *"Walking On The Moon"* [4].

Placed in this context, the lyrics of *"Walking On The Moon"* might appear banal in the extreme, but in comparison to those of Adam Ant's *"Apollo 9"* they are made to sound like a work of great poetry. For anyone wondering why the exploits of McDivitt, Scott and Schweickart were singled out for such praise, it appears the choice of this mission was dictated by mere phonetics, as 'nine' neatly rhymes with other keywords in the song such as 'fine' and 'line'. Artistic merits aside, the song did provide an opportunity for Adam to dress up in flight overalls and pretend to be an astronaut. Although not quite as successful as some of his earlier incarnations, *"Apollo 9"* still propelled him to the heady heights of No. 13 in the UK charts in October 1984.

Worse was yet to come. The rise of 'Rave' and 'Techno' music in the late 1980s & early 1990s, and the current trend for sampling bits and pieces from other records must rate as one of the less salubrious applications of modern computer technology. Since this is primarily a form of dance music and the songs very rarely have anything meaningful to say, the leading exponents have only been too willing to latch 'spacey' themes on to their compositions so as to help them sound a little more exotic to the potential buyer. A few examples plucked from the air include: Back To The Planet and their *"Daydream (Orbital Mix)"*, Darkside's *"Lunar Surf"*, and The Beloved, who offered *"Outer Space Girl (Destination Moon Mix)"*.

For each song which blithely attempts to cash in on space events, there are an equal number which use space/astronomical themes as a coded reference to more Earthly matters, or as more obtuse exercises in metaphysics. This latter approach is epitomised by John Lennon's *"Across The Universe"*, a beautiful little song from The Beatles' 'back to basics' *"Let It Be"* debacle. To the untrained ear the first few lines might sound like a beginners guide to SETI, but as Ray Coleman noted in his biography of Lennon, the song really *"harkens back to the days of gurus and avatars who could save the world"* [5].

Lennon's ex Beatles partner, Paul McCartney, took a similar tack with his 1975 album *"Venus And Mars"*. The packaging of the album sent out all the right signals: a tasteful gatefold sleeve symbolically featuring red and yellow snooker balls, and a free sticker inside which stated the comparative sizes of the planets and their distances from the Sun. Most fan's are of the opinion that the song is actually a veiled reference to Paul and his wife Linda, though McCartney himself has often pointed to its astrological connotations [6].

As for David Bowie and his 1971 search for *"Life On Mars?"*, well believe it or not it's actually a heavily disguised re-working of Frank Sinatra's *"My Way"*.

***Running Down a Dream** - The Bad*

Though it is all too easy to gain the impression that space travel is under attack from all directions, openly criti-

cal songs are a comparative rarity. Space, it seems, is good for the image of a pop star, but nevertheless there have been a number of malcontents who have climbed atop their soap boxes in order to sow the seeds of discontent.

It took quite a time for pop music to shed its 'lovey-dovey', *"I Want To Hold Your Hand"* image. One artist who contributed more than most to breaking down such barriers was Bob Dylan. His 1964 exercise in 'tonal breath control', *"I Shall Be Free - No. 10"*, mimicked the paranoia of his countrymen during the height of the space race. With tongue firmly in cheek, Dylan suggested that the fearsome prospect of the Russian's being the first to reach the golden paved streets of heaven might not bear thinking about!

Dylan would not be the last artist to be struck by the futility of the space race. Similar sentiments can be found in Barry McGuire's *"Eve Of Destruction"*, a trans-Atlantic hit in 1965, and over twenty years later became part of the misanthropic visions of former Pink Floyd frontman Roger Waters. His 1987 song *"The Tide Is Turning (After Live Aid)"* likened the Moon race to a meaningless world title fight between two heavyweight boxers.

The Challenger disaster of January 1986 in which seven American astronauts lost their lives also led to many songs. Though it is the songs which offered emotive tributes to the deceased astronauts which are the best known, other artists chose to mirror the backlash to the disaster. Prince's *"Sign O' The Times"* (1987) made several passing references to the explosion of a rocket ship, while an angst ridden Lou Reed asked in *"Strawman"* (1988) whether the world really needed any more billion dollar rockets and faulty shuttle's?

An even more subliminal reference to Challenger may (or may not) be found within Genesis' *"Domino"*, a track from their *"Invisible Touch"* album which the group was recording at the time of the accident. The song alludes in part to a terrible tragedy being played over and over again on the TV newscasts. While there is no direct reference to Challenger, the connection can be implied if one is prepared to read between the lines. Whether intentionally or not, the song vividly recalls the unconscionable relish with which the TV companies endlessly replayed the footage of the disaster for shock effect.

Not that all 'negative' space songs are filled with doom and gloom. The advent of Direct Broadcasting Satellite (DBS) has proven to be a mixed blessing for most consumers. In 1992 Bruce Springsteen humorously recalled how he had gone through the palaver of buying and installing a satellite dish, only to be dismayed to find that there were *"57 Channels (And Nothin' On)"*.

Though there are many compelling reasons for exploring space, for sheer perversity it would be hard to better the arguments presented in the song *"Tin Machine"*, from the album *"Tin Machine"*, by the band Tin Machine (actually David Bowie in a vainglorious attempt to loose himself in a band identity). The sentiments expressed in this song suggest that the world is willfully heading towards Armageddon, with the singer hoping to take flight to the Moon in his Tin Machine in order to escape from the maelstrom.

The final word must, though, go to 'His Bobness', who stepped down from his pulpit to record the *"Infidels"* album in 1983. Though an undercurrent of 'astrophobia' is detectable on several tracks, the most telling statement comes in *"License To Kill"*, where Dylan ominously suggests that landing on the Moon might actually represent the first step towards the ultimate destruction of the human race. This time he wasn't joking.

The Only Way Is Up - The Good

At the other end of the scale, it would be hard to find a more spontaneous celebration of the excitement generated by the early space missions than *"Happy Blues For John Glenn"*, a song which was recorded by the Texan bluesman Lightnin' Hopkins the very same day that Glenn became the first American in orbit. Legend has it that Hopkins spent most of the morning watching the flight on his landlady's TV. He was so enthralled by events that when he entered the recording studio a few hours later to cut a few tracks he immediately improvised a song about the flight. This was not unusual for Hopkins who possessed the instinctive ability to be able to reel off a song on an impulse. Under normal circumstances *"Happy Blues For John Glenn"* might not have been heard outside the Houston dance halls (including the Sputnik Bar). It just so happened that Hopkins had booked studio time for that day and so the moment was saved for posterity [7].

Though *"Happy Blues For John Glenn"* is little more than a melange of myths which surrounded America's first astronauts (at one point Hopkins refers to Glenn having made half a million dollar bucks from the flight), the song does convey some of the undeniable pride which most American's felt at the time of Glenn's triumphal flight. It was by no means alone. Other recorded tributes to Glenn included: *"The Ballad Of John Glenn"* by Roy West, and (since 'The Twist' was the latest dance craze) Rio de Francesco offered *"The John Glenn Twist"*.

Surprisingly, the songs about Glenn greatly outnumber those dedicated to Yuri Gagarin, who was after all the first man in space. Perhaps sensing that it might be misinterpreted, most musician's in the West shied away from acclaiming Gagarin's flight. It was only long after the event that vinyl tributes to the first man in space became more evident, such as Louis Philippe's *"Yuri Gagarin"*.

The Incomparable Bob Dylan.
SONY MUSIC CORP

"Back In The USSR", the images of Soviet Communism nurtured in the West would imply that the party 'apparatchiks' would have been unsure just how to play the space music card. On one hand Soviet authorities actively encouraged artists of all media to rejoice in the achievements of the cosmonauts, but on the other hand they were deeply suspicious of the influence that decadent rock and pop music might have upon Soviet youth. The details of Soviet space songs are poorly known in the West, but more diligent research will almost certainly uncover many other pieces along the lines of *"The Constellation Of Gagarin"*, and *"Motherland Knows How Her Son Is Flying In Orbit"* (although the roots of both these songs are firmly planted in the traditions of Russian folk and classical music) [8].

Glenn and Gagarin are by no means the only space travellers to have been acclaimed in music. Up With People paid tribute to *"The Walk of Ed White"*, while Casse Culver encouraged America's first female astronaut to *"Ride, Sally, Ride"* [9]. The flight of Canada's first female astronaut also resulted in the *"Song For Roberta Bondar"*.

The most widely praised space mission is undoubtedly that of Apollo 11. Quick out of the starting blocks were The Byrds, who offered *"Armstrong,*

Ring them (Kremlin) bells - Glasnost comes to the music industry in the shape of Louis Philippe's 1989 album 'Yuri Gagarin'.
REPRODUCED BY KIND PERMISSION OF CHERRY RED RECORDS LTD

Aldrin & Collins" in November 1969 as another instalment to their 'space rock' oeuvre. Under the tutelage of Roger McGuinn (who was himself quite an aviation buff) the band had already tackled Einstein's theory of relativity in *"5-D (Fifth Dimension)"* and had sung about a pulsar in *"C.T.A. 102"*. In comparison to these efforts, *"Armstrong, Aldrin & Collins"* is a much less polished song. Written by Zeke Manners, it talks of the flight in the context of the search for universal wisdom [10].

Other songs inspired by the first Moon landing include John Stewart's slightly more selective *"Armstrong"*, The Grateful Dead's *"Standing On The Moon"*, and OMD's (Orchestral Manoeuvres in the Dark) *"Apollo XI"* (complete with 'vocals' by Kennedy, Nixon and all the NASA gang).

Many other groups have shared the predilection for exploring space themes. Performers who have contributed pieces to the catalogue include Steve Miller, Hawkwind, The Ventures, and The Moody Blues, whose 1969 release, *"To Our Children's Children's Children"* was one of the first 'concept' albums devoted to the wonders of space. Devoted Texans, ZZ Top, even offered to provide the in-flight entertainment for the first passenger carrying flight of the Space Shuttle - not that this would have been necessary though since the Johnson Space Centre is already home to Max-Q, an amateur rock band in which several Shuttle astronauts have played [11].

Moving into more avant-garde territory, *"Apollo Atmospheres"* is one of many 'New Age' instrumental pieces which have made a genuine effort to convey some of the serenity of space travel in music. This particular work was commissioned for Al Reinert's impressive documentary "For All Mankind", but unlike many sound-track albums the music stands up to examination in its own right. The work was a collaborative effort between Brian Eno, Daniel Lanois and Roger Eno and was released in 1983. Whether the music can be described as 'rock' is open to question. It lacks an obvious rhythm (drums and bass - the key ingredients on which nearly all rock music is based), and instead creates a more subtle 'textural' collage of sound.

Brian Eno recalls that the music was conceived as an antidote to the way the Apollo 11 mission had been covered on TV, with its: *"uptempo, 'newsy' manner, short shots, fast cuts, and too many experts obscuring the grandeur and strangeness of the event with a patina of down-to-Earth chatter"* [12].

Bringing the story right up to date, Eno also produced *"Zooropa"*, the most recent outing by Irish rock band U2. The first side of *"Zooropa"* closes with *"Stay (Faraway So Close!)"*, a stanza of which picks up on the global village theme and the ability of satellites to take a person anywhere in the world that they want to go.

The band themselves illustrated this to be the case at the start of their "Zoo TV" world tour. During their second show in Miami in March 1992 they actually managed to arrange a link-up with the cosmonauts aboard Russia's Mir orbital station. Well, it must have made a change from calling the White House every night to ask if George was in! [13].

Rock 'n' Roll Suicide

Although this article has shown that the synergism between space and music is quite strong, it must be said that in the grand scheme of things such songs (good, bad, or indifferent) remain very much in the minority. As one commentator on the pop scene recently noted: *"The majority of good, memorable popular music is about love and sex (love more than sex, I'd contend) and not about drugs, or with all respect to Tasmin Archer, the tragic abandonment of the NASA space exploration programme"* [14].

Oh well, its only rock-n'-roll...

Meanwhile, back on Planet Pop... U2's Bono, the latest in a long line of self-styled 'Space Cowboys'. **NOT US LTD**

References

1. Mark Hempsell "No. 1 Hit Targets Moon", ***Spaceflight***, **34**, No. 12, December 1992, p.401.
2. Correspondence, ***Spaceflight***, **35**, No. 1, pp.32-33; p.107; p.119; pp.238-239, No.9, pp.322-323; p.385; **36**, p.67.
3. John Mood "Have You Heard the Stars Tonite?", *Astronomy*, May 1980, p.24-25.
4. Robert Sellers, "Sting - A Biography", Omnibus Press, London, 1989, p.28-29.
5. Ray Coleman "John Ono Lennon - Volume 2 1967-1980", Sidgwick & Jackson, London, 1984.
6. Paul Gambaccini, "Paul McCartney In His Own Words", Omnibus Press, London, 1976, p.90.
7. Mack McCormick, sleeve notes to "Walkin' This Road By Myself", Copyright Fantasy, Inc., 1962 (Re-issued in Europe by Ace Records).
8. "Arena - The Last Soviet Citizen" TV Documentary broadcast by BBC-2, February 19, 1993.
9. "Space Songs", Final Frontier, December 1988, p.40-41.
10. John Rogan, "Timeless Flight - The Definitive Biography of the Byrds", Scorpion Publications/Dark Star, 1981.
11. Nigel Macknight "Meet The Shuttle Rockers" *Space Flight News*, March 1988.
Founder members of Max-Q were Robert Gibson (Lead Guitar), Brewster Shaw (Rhythm Guitar), George Nelson (Bass Guitar) and James Wetherbee (Drums). The current line-up comprises of Gibson, Pierre Thout (Guitar), Kevin "Chilly" Chilton (Guitar), Susan Helms (Keyboards) and Carl Walz (Vocals) Bernhard Harris (Saxophone) has also appeared with the band. (Info supplied by Astro Info Service).
12. Eric Tamm, "Brian Eno His Music and the Vertical Color of Sound", Faber and Faber, London, 1989 p.143.
13. Sam Goodman, "U2 - Burning Desire", Castle Communications PLC, Surrey 1993, p.194.
14. Jeremy J. Beadle, "Will Pop Eat Itself? - Pop Music in the Soundbite Era", Faber and Faber Limited, London, 1993, p.239.

"Astronaut" Award

Sir, I enclose a transparency which I recently received from the MTV network. While the film Industry has its "Oscars", an "Astronaut" is a coveted prize in the music biz. The statuettes are presented each year at the MTV Video Music Awards.

DARREN BURNHAM
Oxford, UK

Space Oldies

Sir, I have looked through my old phonograph records and found a 331/3 RPM long-playing album of space music that I purchased In 1961. It is titled *Fantastica - Music from Outer Space* and consists of orchestral music with synthesized sound effects. The album was composed and conducted by Russ Garcia and Issued by Liberty Records.

The twelve tracks are titled: *Into Space; Nova; Lost Souls of Saturn; Monsters of Jupiter; Water Creatures of Astra; Venus; Red Sands of Mars; Goofy Peepl of Phobos; Volcanoes of Mercury; Birth of a Planet; Frozen Neptune; Moon Rise.*

I also have a 45 RPM single titled *Sail Along Silvery Moon.* It is an instrumental by the Billy Vaughan Orchestra. If I remember correctly, it was popular in the summer of 1957, just a few months before Sputnik was launched.

GARY S. CAMPBELL FBIS
Texas, USA

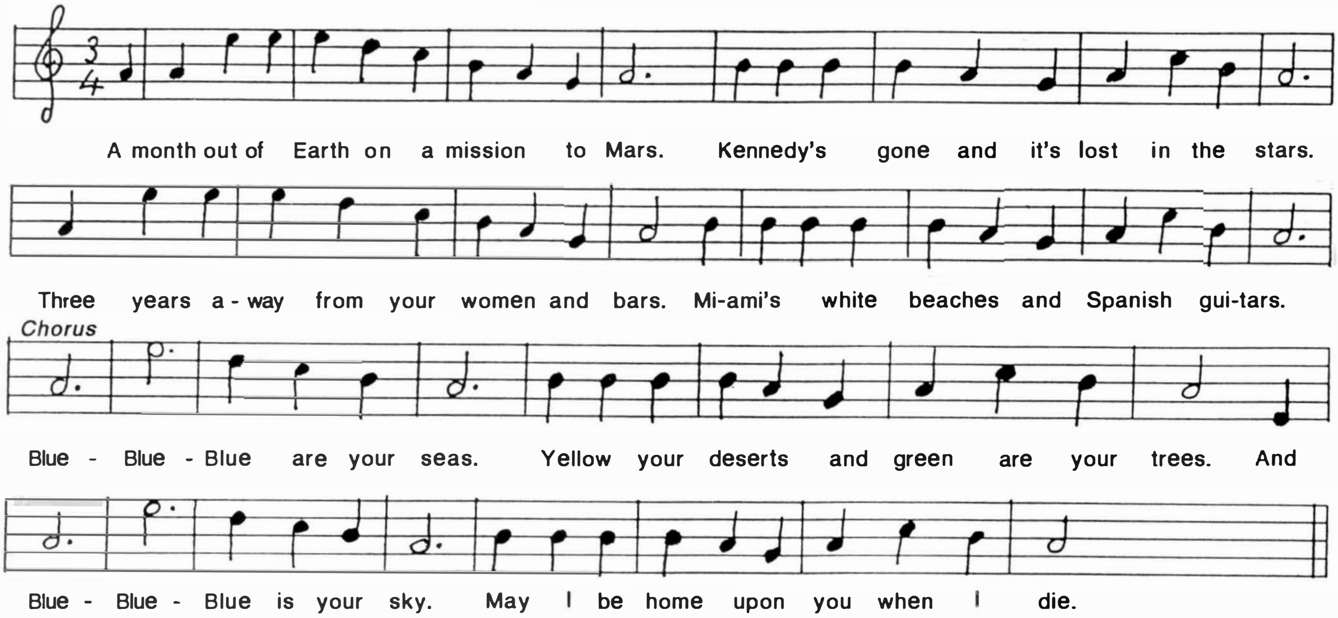
The Editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment on these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

'Mars Mission'

Sir, To the ever growing catalogue of space songs I submit my own song *Mars Mission.* It Is a dramatic song using the technology of the day.

MARS MISSION

Words and music by Ted Edwards. © 1990 Ted Edwards.



2. A year slips away in the barren routine.
Pressing the buttons and watching the screen.
The sun rolls around and you try to stay keen,
Remembering sights upon Earth you have seen.

3. Black - Black - Black is the day.
The unwinking jewels in finest array.
Blue, red and yellow, they shine and decay.
Shedding their light on your home far away.

4. The planet of war has a deep ruddy glow.
Timelessly turning so smooth and so slow.
Sometimes you're high but at others you're low.
Wishing that Earth was the planet below.

5. The landing is heavy. The cost of it's dear.
Your guts are alive with the serpent of fear.
In the alien dust you inter with a tear,
The mortal remains of the First Engineer.

6. Hard is the labour and long is the day.
Cold is the desert but good is the pay.
Hearts are gone homeward but you have to stay,
And work for the window a whole year away.

7. Repairs are completed and you won the race.
Blast into orbit and head back to base.
Back to your people to touch and embrace.
Back to the jewel that's hanging in space.

8. You can't breathe the air as you try to survive.
The damned hydroponics have taken a dive.
The course is all set and the ship will arrive,
But when you're in orbit will you be alive?

9. You see the blue ball like a marble ahead.
The hold's full of rocks but the crew has been bled.
You're still alive but some others are dead.
Just part of the cost of the planet of red.

10. The glare of the shuttle as you watch her rise,
Brings joy to your belly and damp to your eyes.
Mars was your challenge and Earth is your prize.
Soon you'll be under the blue of her skies.

TED EDWARDS
Manchester, UK

"Shooting Rubber Bands at the Stars" - ***DISCOGRAPHY***

Compiled by Darren L. Burnham

The Police went 'Walking on the Moon'. REPRODUCED BY KIND PERMISSION OF A&M RECORDS

Singles

Adam ANT	Apollo 9 (1984 CBS - A 4719)
Tasmin ARCHER	Sleeping Satellite (1992 EMI - EMI 233)
The BELOVED	Outer Space Girl (1993 EastWest - YZ726)
Jonathan KING	Everyone's Gone To The Moon (1965 Decca - F 12187)
Barry McGUIRE	Eve of Destruction (1965 RCA - 1469)
The POLICE	Walking On The Moon (1979 A&M - AMS 7494)
PRINCE	Sign O' The Times (1987 Paisley Park - W 8399)
Bruce SPRINGSTEEN	57 Channels (And Nothin' On) (1992 Columbia - 6581387)
TIN MACHINE	Tin Machine/Maggie's Farm (Live) (1989 EMI-USA - MT 73)
U2	Stay (Faraway, So Close!) (1993 Island - CID 578/858 077-2)
Roger WATERS	The Tide Is Turning (After Live Aid) (1987 Harvest - EM 37)

Albums/Album Tracks

Adam ANT	VIVE LE ROCK (1985 CBS - 26583) includes Apollo 9
The BEATLES	LET IT BE (1970 Apple - PCS 7096) includes Across The Universe
David BOWIE	HUNKY DORY (1971 RCA - SF 8244) includes Life on Mars?
The BYRDS	FIFTH DIMENSION (1966 CBS - SBPG 62783) includes 5D (Fifth Dimension) and Mr Spaceman
	YOUNGER THAN YESTERDAY (1967 CBS - SBPG 62988) includes C.T.A. 102
	BALLAD OF EASY RIDER (1969 CBS - SBPG 63795) includes Armstrong, Aldrin & Collins
Bing CROSBY	THE BEST OF BING (1988 MCA - DMCL 1607) includes Swinging On A Star #
Bob DYLAN	ANOTHER SIDE OF BOB DYLAN (1964 Columbia - BPG 62429) includes I Shall Be Free No. 10
	INFIDELS (1983 CBS - 25539) includes License To Kill
Jerry ENGLER	RARE ROCKABILLY VOL. 3 (Various Artists) (1983 MCA - 1757) includes Sputnik #
Brian ENO	APOLLO: ATMOSPHERES & SOUNDTRACKS (1983 Editions EG - ENO 5)
GENESIS	INVISIBLE TOUCH (1986 Virgin - GEN CD2) includes Domino
The GRATEFUL DEAD	BUILT TO LAST (1989 Arista - 260326) includes Standing On The Moon
Gustav HOLST	THE PLANETS - Herbert Von Karajan and the Berliner Philharmoniker (1981 Deutsche Grammophon - 2532019)
Lightnin' HOPKINS	WALKIN' THIS ROAD BY MYSELF (1962 Bluseville - 820*) includes Happy Blues for John Glenn
Elton JOHN	ROCK OF THE WESTIES (1975 DJM - DJLPH 464) includes Dan Dare (Pilot of the Future)
Lonnie MILEY	VOL. 18 - THE BOP THAT NEVER STOPPED (Various Artists) (1988 Buffalo Bop - BB2021) includes Satellite Fever #
The MOODY BLUES	TO OUR CHILDREN'S CHILDREN'S CHILDREN (1969 Threshold - THS 1)
O.M.D.	SUGAR TAX (1991 Virgin - CDV 2648) includes Apollo XI
Louis PHILIPPE	YURI GAGARIN (Cherry Red Records - ACME 23CD)
The POLICE	REGATTA DE BLANC (1979 A&M - AMLH 64792) includes Walking On The Moon
PRINCE	SIGN O' THE TIMES (1987 Paisley Park - 925 577 2)
Lou REED	NEW YORK (1989 Sire - 925 829-2) includes Strawman
The ROLLING STONES	THEIR SATANIC MAJESTIES REQUEST (1967 London - TXS 103) includes 2,000 Light Years from Home
Bruce SPRINGSTEEN	HUMAN TOUCH (1992 Columbia - 471423 2) includes 57 Channels (And Nothin' On)
John STEWART	CANNONS IN THE RAIN/WINGLESS ANGLES (Bear Family Records - BCD 15519) includes Armstrong #
Bill THOMAS	ROCKABILLY WORLD (Various Artists) (1986 White Label - WLP 8908) includes The Sputnik Story #
TIN MACHINE	TIN MACHINE (1989 EMI-USA - CDP-7-91990-2)
U2	ZOOROPA (1993 Island - CID U 29) includes Stay (Faraway So Close!)
Roger WATERS	RADIO KAOS (1987 EMI - KAOS 1) includes The Tide Is Turning (After Live Aid)
Jeff WAYNE	WAR OF THE WORLDS (1978 CBS - 96000)
WINGS	VENUS AND MARS (1975 Apple - PCTC 254)

Notes in parenthesis indicate: Year of Release, Record Label, and Catalogue Number.
All catalogue numbers refer to original UK issues (ignoring re-releases and compilation albums etc.), except for those marked #, which indicate the most recently available re-issue. For titles marked *, US catalogue numbers have been given.

'Space Music' Competition

With the spotlight falling, in this issue, on 'Space Music', this month's competition picks up the theme with a few multiple choice questions on the subject.

Prizes: The first two correct entries to be opened after the closing date of 2 June 1994 will receive an autographed copy of the book:

ODYSSEY

The Authorised Biography of Arthur C. Clarke

by Neil McAleer

To Enter: Answer A, B, or C to each of the following four questions.

1. Which 'Fab' 60s person produced the Bonzo Dog Doo-Dah Band's 1968 hit *"I'm The Urban Spaceman"* under the pseudonym 'Apollo C'? A. John Lennon B. Paul McCartney C. George Martin ....
2. Which controversial musical featured the song *"Walking In Space"*? A. Jesus Christ Superstar B. Starlight Express C. Hair ....
3. Which diminutive American singer anonymously duetted on Big Dee Irwin's hit version of *"Swinging On A Star"*? A. Brenda Lee B. Little Eva C. Eartha Kitt ....
4. Which American band recently scored a hit with the song *"Man On The Moon"*? A. R.E.M. B. Nirvana C. The Spin Doctors ....

Post to: The British Interplanetary Society,
27/29 South Lambeth Road,
London SW8 1SZ, England
To arrive by first delivery on 2 June 1994.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

Title/Name ....

Address ....

....

Book Notices

Advances in Space Biology and Medicine Vol 2

S.L. Bonting, JAi Press Ltd., 28 High Street, Hampton Hill, Middlesex, TW12 1PD, 1992, 304pp, £53.

Both space biology and medicine are relatively young fields concerned with the effects of the space environment, such as low gravity and radiation, on living organisms. Although considerable data has been accumulated from flights over the past 30 years, there is still much to learn about the mechanisms of these effects, the adaptation of the organisms to them and possible counter-measures. Fundamental problems are also posed, such as the role of gravity in the evolution, development and reproduction of life on Earth and perhaps elsewhere.

For these and similar reasons, the aim is to produce this series of volumes on an annual basis and to endeavour to bring the new findings and accomplishments to the notice of a much wider group, beyond the relatively small band of biologists and physiologists already involved in space experimentation.

This book, Vol 2 in the series, develops all these space-related areas in nine contributed papers. The first reviews the general mechanisms of the effect of weightlessness on the human body and is followed by several others which examine how the body alters and/or adapts under such conditions and features a particularly interesting paper on Human Nutrition under Extraterrestrial Conditions.

Two further contributions examine the effects of space flight on cells and a final paper postulates on conditions leading to the creation of life, primarily from the point of view of exobiology.

Astrophysical Jets

D. Burgarella, M. Livio and C.P. O'Dea, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1993, 315pp, £35.

Though differing widely in both scale and energy, the jets observed in young stellar objects and in extragalactic radio sources exhibit a remarkable similarity in their morphology. The problem is to know what physics they share.

To answer this, researchers in the fields of both extragalactic and stellar jets came together with the aim of identifying the common underlying physics. It was obviously not to be expected that a full understanding of the jet acceleration and collimation mechanisms would emerge from such a meeting but it did provide an opportunity to clarify both similarities and differences.

The result is this dozen invited reviews from internationally renowned figures presented in an edited and coherent volume. Topics discussed include acceleration and collimation mechanisms, magnetised accretion disks, thermal and synchroton jets, optical and molecular outflow and emission-line radiative bow shocks. They give a unique overview of astrophysical jets which crosses the usual boundaries of scale and energy and of theory and observation. Together, they summarise our present knowledge, highlight outstanding problems and provide a focus for future work.

The Box of Stars: A Practical Guide to the Night Sky, its Myths and Legends

C. Tennant, Chatto & Windus, 20 Vauxhall Bridge Road, London, SW1V 2SA, 1993, £14.99.

Two completely different ways of looking at the sky are combined in this guide which seeks to bring the myth and magic back into stargazing. The box contains two maps of the night sky together with 32 beautiful replicas of hand-painted 19th century coloured 5½" x 7¾" cards, depicting the strange beasts and mythological figures which gave their names to the constellations. The cards are pierced with holes so that, when held up to the light, these glitter and highlight the stars. Included is a booklet which explains how to use both cards and maps to locate and recognise stars and constellations and describes some of the myths and legends surrounding them.

Space Satellite Handbook

A.R. Curtis, Gulf Publishing Company, Book & Software Division, PO Box 2608, Houston, Texas 77252-2608, USA, 1994, 346pp, $39.

The value of this guide to the thousands of satellites, payloads, platforms, rockets and debris from all countries launched into orbit is shown by the issue of a third edition. It provides detailed information on all the man-made objects still in orbit, some dating from as far back as 1958, as well as the thou-

sands which have already re-entered the Earth's atmosphere. The latest orbital data of all these objects, which occupies nearly half the book, is detailed in listings which give the official international number for each satellite as well as its popular name, launch date and country of origin. Orbital parameters and other data include inclination, apogee and perigee. Sections deal with satellites for particular purposes.

Wernher von Braun: Crusader for Space: An Illustrated Memoir

E. Stuhlinger and F.I. Ordway III, Krieger Publishing Company, PO Box 9542, Melbourne, FL 32902-9542, USA, 1994, 168pp, $29.50.

This volume presents a retrospective view, based on numerous pictures of Dr von Braun, of a man who became recognised as a unique genius during his extraordinary lifetime. His contribution to the exploration of space brought him accolades from all over the world, not least from our own Society with the Award of its Gold Medal. He was destined to become friend and confidante to many world-renowned political, military, social, industrial and scientific leaders.

Even during World War II, while developing the V2, von Braun's belief never wavered that the rocket was to be the means to transport man into space and his subsequent long career in America, devoted to space exploration, brought many triumphs, culminating with the Apollo Moon landings.

The collection of photos includes many from personal archives which have never before been published. Altogether, they provide a remarkable insight into the life and work of an outstanding space pioneer.

The Man Who Sold the Milky Way: A Biography of Bart Bok

D.H. Levy, The University of Arizona Press, 1230 N Park Avenue, Suite 102, Tucson, Arizona 85719-4140, USA, 1993, 246pp, $35.

This book, based on more than 50 interviews with Bok undertaken during the two years before his death in 1983, shows not only what made Bok an exceptional scientist but also what it was like to be an astronomer during an era when significant advances were being made in his fields of interest.

It describes Bok's professional career which began at the University of Leiden. He became Wilson Fellow in astronomy at Harvard Observatory in 1929, moved on to the Australian National University in 1957 and, in 1966, became Head of the Department of Astronomy and Director of the Steward Observatory at the University of Arizona.

Bok was always keen on educating the public, whether informing them about his particular studies of the Milky Way or debunking astrology. He devoted a lifetime of commitment to that end. In reviewing the achievements that made Bok one of the outstanding astronomers of the 20th century, the author also describes the harassment suffered by Bok at the hands of Senator Joseph McCarthy and the events which subsequently caused him to leave Harvard.

Atlas of Neptune

G.E. Hunt and P. Moore, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1994 84pp, £17.95.

The encounter of NASA's Voyager 2 spacecraft with Neptune in August 1989 provided a wealth of new information about the planet, its ghostly rings, remarkable satellites and environment, and gave rise to a number of amazing new discoveries.

This book starts with a fascinating historical background to the discovery of Neptune, its satellites and rings and then goes on to describe the Voyager Mission in detail, thus highlighting the dramatic leap in knowledge and understanding of the Neptunian environment which took place as a result of the Voyager encounter.

The latest information is presented and illustrated with many pictures from the mission. As it seems likely that no further spacecraft visits to the outer planets will take place for several decades to come, this book gives a very readable and extremely timely summary of our knowledge of the most distant planet yet visited.

The Birth of NASA: The Diary of T. Keith Glennan

J.D. Hunley, Editor, US Government Printing Office, Superintendent of Documents, Mail Stop SSOP, Washington, DC 20402-9325, 1993, 396pp, $24.

The successful Soviet launch of the first Sputnik on 4 October 1957 created an enormous sensation in the United States, giv-

ing rise to doubt on the part of many Americans as to the effectiveness of their science, education and military capabilities. Above all, they feared that the Soviet Union had obtained a lead in the race to develop long-range missiles. It was in this crisis atmosphere that President Eisenhower and the US Congress created a new agency - the National Aeronautics and Space Administration - which officially came into being on 1 October 1958.

In this fasciating book, part diary and part recollection, T. Keith Glennan, the first NASA administrator, relates the story of how he and others both inside and outside the agency worked to plan and organise a viable space programme that ultimately put 12 men on the Moon. In the process, Glennan also reveals a great deal about Eisenhower personally, about the US capital at the end of the 1950s and beginning of the 1960s, and about individuals such as Wernher von Braun, the charismatic leader whose rocket team designed the Saturn launch vehicles that propelled the astronauts to lunar orbit.

This diary is a 'must' for anyone interested in the early history of the US space programme and the atmosphere in which it arose. The author's narrative is supplemented by an introduction which traces his Yale education and subsequent career as an engineer, AEC commissioner and president of the Case Institute of Technology. It shows how this background prepared him for his role in creating a NASA "that could carry out a broad-based scientific and technological program" suitable for the post-Sputnik era.

Also included in the book is a biographical appendix sketching the careers of key participants in the story related.

These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate. Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

COMPUTER SOFTWARE

Mars Explorer

Virtual Reality Laboratories Inc, 2341 Ganador Court, San Luis Obispo, California 93401, USA. Available on CDROM only. Requires a 386 or 486 IBM PC compatible with 4 Mbytes memory, CD-ROM drive, Microsoft compatible mouse and driver, MSDOS 3.0 or higher. Supports MCGA, VGA or SVGA (preferred) video adaptors. $69.95.

Mars Explorer is software that takes advantage of the high storage capacity offered by the CDROM format to provide access to over 200 Mbytes of Viking Orbiter imagery processed into a mosaic covering the entire Martian surface between +/-50 degrees of latitude. The program opens with a low resolution map of Mars and users simply point the mouse cursor at any feature of interest on the map and then view the corresponding image, which can be enlarged in four stages up to a magnification of 64 times. While viewing the image, it can be scrolled North, South, East or West across the screen and adjusted for contrast and brightness. Once a suitable image has bene set up, Mars Explorer can export it as a PCX file (which is a widely supported graphics file format) for use in other applications.

Prominent features in images may be identified, more often than not, by clicking on them with the mouse cursor, which yields the IAU approved name, latitude and longitude and type of feature. Feature names and a coordinate grid may be overlaid on to the image if desired. Users can also select a feature by name from an alphabetical list which is accessible from the map screen and Mars Explorer will automatically locate and display the appropriate image. Mars Explorer can also show Mars as a rotating globe but the resolution suffices only for viewing the major albedo features.

Mars Explorer supports screen resolutions up to 640 x 480 for a range of video adaptors, but not for the adaptor in the review machine (Orchid Fahrenheit 128D) on which only 30 x 240 resolution images could be obtained. Fortunately, an enquiry to the publishers produced a solution and the necessary fix was installed to the hard disc of the review machine. Normally Mars Explorer runs from the CDROM directly, so installation is not required.

With the full resolution available, there was a dramatic increase in image detail so that the canyons, volcanoes, channels, dune fields and landslips could be clearly seen. It was easy to use the program to locate interesting features and to adjust the viewing parameters to bring out the best detail: most users will not need to refer to the 14 page user manual very often. The most striking thing about the program is that it allows the user to study the interrelationships between the various Martian landforms free from the constraints of a photographic atlas. The capability to adjust viewing parameters makes the images far more accessible to the non-specialist user than a collection of photographs which are necessarily taken from fixed viewpoints and processed with fixed brightness and contrast settings.

Mars Explorer complements, but does not replace, existing commentaries on Mars such as the Viking project reports and Carr's "The Surface Of Mars". It will appeal to those with an interest in geology in general or Mars in particular.

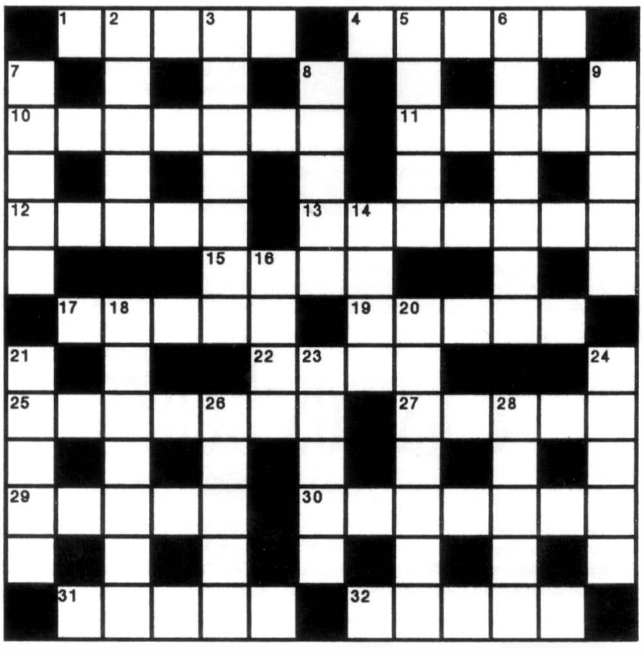
Spaceflight Crossword

No. 9

ACROSS
- 1+4. Boring tool with helical grooves (5,5)
- 4. See 1. Across
- 10. Luck
- 11. Pertaining to the ear
- 12. Expel
- 13. Space probe on highly-inclined solar orbit
- 15. Set sail for this girl's name
- 17. Yellow fossil resin
- 19. Increase in salary
- 22. Governor's assistant
- 25. Maximum
- 27. Revolt
- 29. Words that are names
- 30. Natural abode
- 31. Rubber rings for Shuttle touchdown
- 32. Chase (ana.)

Solution will appear in the June issue.

DOWN
- 2. Less well
- 3. Space ______
- 5. Prepared
- 6. They play harp-like instruments
- 7. Later in time
- 8. Planet
- 9. Nearby
- 14. Rendered fat
- 16. US-British-Dutch satellite telescope launched in 1983
- 18. Planet
- 20. Requiring free oxygen for respiration
- 21. Soviet military satellite programme
- 23. Pertaining to irritation in the skin
- 24. Planet
- 26. Come after
- 28. Take a dip



Solution to Crossword No.8.
ACROSS: 7. Detach; 8. Perish; 10. Artemis; 11. Night; 12. Drop; 13. Erode; 17. Meant; 18. Soho; 22. Ozone; 23 Mission; 24. United; 25. Partly.
DOWN: 1. Edwards; 2. Station; 3. Scamp; 4. Kennedy; 5. Rings; 6. Chute; 9. Astronomy; 14. Severed; 15. Society; 16. Molniya; 19. Soyuz; 20. Sonic; 21. Oscar.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: All Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.
Admission is by ticket only. Members should apply in good time enclosing a sae. Subject to space being available each member may also apply for a ticket for one guest.
It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight/JBIS*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

4 May 1994 — 7-8.30pm

The STRV Project: 'Two UK Spacecraft to Brave Hostile Orbit so Others can Live Longer'

K. A. Ryden

This lecture will describe the design and entire mission of the two 'STRV' satellites, These satellites built by the Defence Research Agency, Farnborough are awaiting launch on an Ariane vehicle: they will be spending their relatively short lives in an exceptionally severe orbital environment. The purpose of their mission is to answer questions about the true effectiveness of a wide range of new and untried space technologies.

1 June 1994 — 7 - 8.30 pm

The Microlight Solar Sail

C. Jack

Recent advances in microelectronics make possible a new solar sail concept: a tiny rigid sail just a few metres in diameter which could be controlled purely by electronics, without moving parts. The key components of the craft will be a tiny CCD camera developed at Edinburgh University, which can act as both attitude sensor and data gathering device, high performance solar cells, providing a few watts of power for control and communication, and a radio which uses the sail itself as a directional antenna.

The craft will be highly manoeuvrable, compared.to a large sail, and will be capable of some ambitious missions, including rendezvous with near-Earth asteroids.

6 July 1994 — 7 - 8.30 pm

Life Support In Space and Lessons for Earth

R. Huttenbach

The talk will describe the features of systems used to sustain astronauts when they live in space. These include the revitalisation of the air they breath, the supply of water and food they consume and the management of the waste they produce. All must be integrated into loops that can be open or regenerative.

The technology of biological life support and the evaluation of how closed a system should be, or can be, provide important insights into how we might use resources on Earth.

First Announcement

APOLLO 11

25th Anniversary Celebration

at

The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1

on

16th July 1994, 6.30 - 10.00 pm

The Society is arranging to mark the occasion of the first manned landing on the Moon twenty-five years ago with this special evening reception and programme.

Confirmation of arrangements, details of the programme and other information will appear in the next issue of *Spaceflight*.

7 September 1994 — 7 - 8.30 pm

What Must We Change For Low Cost Space: Management, Politics or Technology

C.J. Elliott

Early space programmes were cheap and effective. We have now reached the position where a mission like Envisat takes 15 years and costs 1500MAU, justified on the grounds that large missions bring an economy of scale. This lecture examines the drivers that force up the costs of space missions and seeks different ways of behaving that might lead to a virtuous spiral of falling costs and shorter development programmes.

6 October 1994 — 7 - 8.30 pm

The First Manned Lunar Landing Spacecraft: Its Design, Manufacture, Ground Test and Mission

R. Fleisig

This paper describes will illustrations the Apollo 11 space vehicle with emphasis on Lunar Module 5 (LM-5). Development tasks, including test articles and facilities are explained. Manufacturing flow and extensive ground testing phases are detailed. Finally the mission itself with the LM trajectories, important events and key astronaut activities are reviewed.

LIBRARY

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

Nominations for Election to Council

Council nomination forms are obtainable from the Executive Secretary. These must be completed and returned not later than 12 noon on May 20, 1994. If the number of nominations exceeds the number of vacancies, election will be by postal ballot. Voting papers will then be prepared and circulated to all Corporate Members.

SYMPOSIA & CONFERENCES

4 June 1994 — 10-4.30 pm

Soviet Astronautics

* * *

23 June 1994 — 10-4.30 pm

Space Industrialisation as a Response to Global Threats

Papers to be presented at this Symposium include: 'Space Industrialisation as a Response to Global Threats - An Overview', 'The Exploitation of the Moon to Substitute Terrestrial Resources', 'Sub-Orbital Tourism - The Key to Space Industrialisation', 'The Space Option and Our Future: Some Considerations on the Thermal Burden'.

* * *

15 September 1994 — 10-4.30 pm

Space Transportation and Infrastructure

This one day symposium will include papers on 'The Skylon Spaceplane', 'The Architecture of the Space Infrastructure with Advanced Spaceplanes'.

* * *

9-14 October 1994

45th IAFCongress *"Space and Cooperation for Tomorrow's World"*

The 45th Congress of the International Astronautical Federation will be held in Jerusalem, Israel, October 9-14, 1994. There are 98 technical sessions planned.

* * *

Offers of papers for Society Symposia would be welcome. Please send Title and Abstract and Indicate which Society Symposium to the Executive Secretary. *Advance Registration is necessary. Limited undergraduate student concessions available on request.* Registration: Forms are available from the Executive Secretary. Please enclose a sae and indicate the Symposium you wish to attend.

48 Gurton Drive

JOIN THE BRITISH INTERPLANETARY SOCIETY

When you join the British Interplanetary Society *Spaceflight* will be mailed directly to your home address each month, hot off the press.

As a member of the Society you will become part of a worldwide organisation which promotes space and astronautics and be able to attend the wide range of Society meetings, visits and other special events. Members also receive discounts on Society publications and entry to symposia.

This offer includes a choice of FREE GIFTS viz: official Society pin-on lapel badge, a voucher that entitles you to £5 OFF any title in the BIS Video Collection or a copy of the 218pp book *Citizens of the Sky* by R.C. Parkinson.

APPLICATION FOR MEMBERSHIP OF THE BRITISH INTERPLANETARY SOCIETY

I apply for Membership which will include a subscription to ***Spaceflight*** and one of the following special offers:

a voucher worth £5 off the price of any title in the BIS Video Collection ☐ *
or an official Society pin-on lapel badge ☐ †
or a copy of the book by Robert C. Parkinson "Citizens of the Sky" ☐ †

I enclose £38 (US$69) for a 12 month subscription from January-December 1994

A special reduced rate of £26 (US$47) is available for those under 22 or over 65 years on 1 Jan 1994.

Full Name (please PRINT surname first)	Title
Postal Address	Date of Birth
Professional Affiliation & Address (if applicable)	Job Title or Position
Signature Date	*Application constitutes acceptance of the Society's Constitutional Rules*

Send to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England

NB Videos available in VHS PAL format only. *Offer closes 30 June 1994. † While stocks last.

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Columbia's Two Week Mission

Space Launches

Euro Space Center

Astronomical Notebook

Space at JPL

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Opinions in signed articles are those of the contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society.

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Spaceflight

The International Magazine of Space and Astronautics

Published By The British Interplanetary Society

Vol. 36 No. 6 June 1994

Space Education

Feature

News & Events

Space Miscellany

Front Cover: **A part of the exhibition staged by the British Interplanetary Society for a one-day event in London entitled 'SPACE - From Imagination to Reality with the BIS'. The event was organised in support of SET7 - a week-long national celebration of science, engineering and technology. In the picture is Mr Alistair Scott who is Marketing Manager of British Aerospace.**

–European Rendezvous

High Power TV Satellite

British Aerospace Space Systems Limited, together with its Satcom International* partner Matra Marconi Space, will supply the European Telecommunications Satellite Organization (EUTELSAT) with its first high power communications satellite specifically designed for the direct broadcast of television programmes to homes, cable stations and communities.

The satellite will be positioned at 13° East and is expected to be operational by the autumn of 1996 with an operational life of 15 years.

The satellite will provide two coverage areas:

- Superbeam - small antenna reception over Western and Eastern Europe
- Widebeam - coverage from Russia to the Canary Islands, reaching to the southern CIS Republics and the Gulf States.

The satellite is the first version of their highly successful Eurostar range of communications satellites to be dedicated solely to the high power transmission of television programmes. British Aerospace will build the satellite's structure, power and thermal control subsystems and the antennas used to transmit the television signals to the ground.

Eurostar

There are eight Eurostar satellites currently operational and four further satellites in production, one of which is scheduled for launch later this year.

Four Eurostar satellites are in service with Inmarsat providing a range of communications services to mobile users throughout the world. British Aerospace Space Systems was prime contractor for this series of Inmarsat 2 satellites. The company was also prime contractor for three of Inmarsat's first generation satellites.

Matra Marconi Space has been prime contractor for four Eurostar-based TELECOM 2 satellites which carry French National telecommunications. Two are already operational and the other two are scheduled for launch in 1995 and 1998.

Matra Marconi Space was also prime contractor for the two Spanish Hispasat communications satellites which are used for Spanish government and civil télecommunications including the direct broadcast of TV. Matra Marconi Space will act as prime contractor for this latest contract.

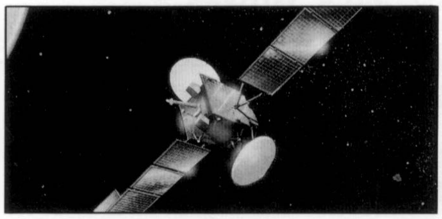
British Aerospace Space Systems Limited is prime contractor for the ORION satellite which will carry commercial transatlantic communications when it is launched in October this year.

*Created in 1980, Satcom International is the legal, managerial expression of long lasting co-operation between British Aerospace Space Systems Limited and Matra Marconi Space. Both companies have been involved together in space activities since the early 1960s, and have developed complementary ranges of expertise that have placed them at the forefront of satellite and space equipment design and manufacture.

Eurostar Spacecraft

Mass into GTO:	1500-3000kg
Payload mass:	up to 500kg
Payload power:	up to 4kW
Design lifetime:	12 years
Operational (station keeping) lifetime:	up to 15 years
(dependent on launch vehicle)	

MATRA MARCONI SPACE



Matra Marconi Space is prime contractor for the EUTELSAT programme. MMS

European Solar Cells for Space Probes

Unlike satellites which operate in near-Earth orbit and are normally powered by solar cells arrays, deep-space probes may experience a solar intensity which is less than 5% of that near the Earth. This was the case for ESA's Ulysses which before reaching the Sun's poles had first to travel to Jupiter. Moreover, at that distance the temperature of the solar arrays goes down to about -100°C. Current solar cells which are 10 to 20% efficient in near-Earth orbits are not generally made to operate at these low temperatures and solar intensities.

Until now, deep space probes have used thermonuclear power generators like the so called RTGs (Radioisotope Thermoelectric Generators), but as RTG technology is not available in Europe, European industry, under contract with ESA, has undertaken the development of a power source based on very high-efficiency solar cells.

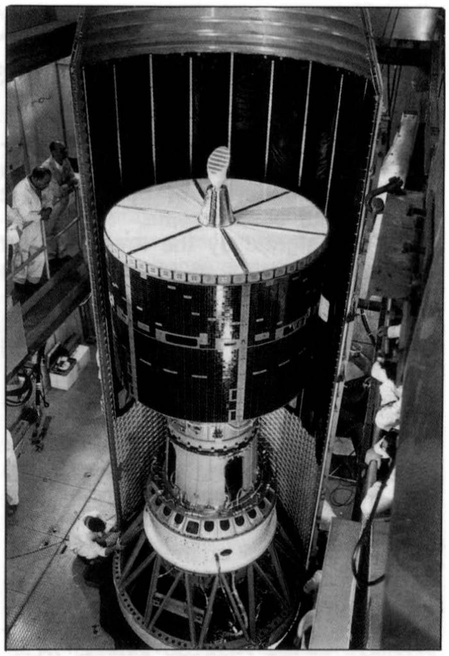
Under low-light intensity conditions, 25% efficiency has been achieved on 6x4 cm Silicon cells. The 25% mark represents the highest efficiency ever reached worldwide with Silicon cells without special optical concentration devices to increase the amount of light collected. A little over one year ago, solar cells of the Gallium Arsenide (GaAs) type had reached 23% efficiency on 2x4 cm cells.

The work with Silicon solar cells was carried out by a team led by DASA (Heilbronn, Germany) with CISE (Milan, Italy) as subcontractor. (CISE were also responsible for the development of high efficiency GaAs solar cells).

ESA expects that the new high performance Silicon solar cells could profitably be used in future European deep-space missions such as the recently approved Rosetta cometary mission.

SKYNET Anniversary

1994 is the Silver Jubilee of the SKYNET Programme and 25 years of MOD involvement in satellite communications. It is also the 20th anniversary of SKYNET 2B, one of the UK Ministry of Defence's early military communications satellites built by Marconi Space, Portsmouth, now Matra Marconi Space.



SKYNET 2B being prepared for launch in 1974. DRA/MMS

SKYNET 2B was launched in 1974 into geostationary orbit and was, in fact, Europe's first operational communications satellite and serves to remind us of the approach of yet another anniversary and another British success story; the Golden Jubilee of the publication by Arthur C. Clarke of his revolutionary concept of the geostationary orbit.

With an original design life of 5 years, and long since exhausted of any operational value, SKYNET 2B should have taken its place as another piece of silent flotsam in the great satellite graveyard in space. Amazingly, however, recent measurements taken at the Defence Research Agency's satellite test facility at Defford have not only shown that the two communication transponders are still functioning, but that they still meet their original specifications.

Satellite engineers will be all too familiar with the fickle, almost perverse nature of the Travelling Wave Tube Amplifier (TWTA), the satellite's radio transmitter. SKYNET 2B's TWTA is however still performing at 16 watts.

During its operational life in the 1970s, SKYNET 2B provided the backbone of the UK's strategic military communications and spawned some world-beating new Earth station types for use by the British Forces.

SKYNET 2B, shaped like a drum, is a 'spinner' and achieves its basic stability through an initial spin-up from the final stage of the launch rocket. Just like a spinning top, it has faithfully maintained this spin at 90 rpm in the same direction in space for all of its 20 year life. This initially surprising fact may seem odd but there really is not much in space to slow it down, just the odd bit of solar wind!

Other bits of technology, which by all normal standards should have failed by now, include the solar cells, the mechanical 'de-spin' antenna mechanism and the infra-red Earth sensors. The only thing that has failed is the NiCad battery pack. (It's always the batteries that let you down!). This battery failure produces an interesting effect each time the satellite enters the Earth's shadow. In the absence of any solar electrical power, the payload switches off and the antenna 'spins-up' causing the overall satellite spin rate to drop slightly. The spin returns to normal when the antenna is de-spun again. This has been happening most days for the past 10 years or so, causing 4000 'on-off-on' switches without a failure!

The continued successful operation of the payload is a tribute to the early research by DRA and the skill and tender loving care exercised by the Matra Marconi engineers - perhaps with a small pinch of luck. What it does prove is that Space is really quite a benign place (for satellites!) and bodes well for the continued successful operation of MOD's current British-built (BAe and MMS) SKYNET 4 satellites, and their replacements at the turn of the century.

When SKYNET 2B exhausted its operational life, it lost the power to maintain its precise perch in geostationary orbit and began a long lazy 'walk-about' in space, swinging like a pendulum in an equatorial orbit from 0° to 150° in a roughly two year cycle. Like the real old trouper it is, it recently crept shyly back over the UK horizon as if to join in its own birthday party.

Happy Anniversary SKYNET 2B, unused and often out of sight but not forgotten. It is good to have you back to share in your own 20th birthday celebrations and to testify to British space engineering expertise.

Two More SKYNET 4 Satellites

The UK Ministry of Defence (MOD) has awarded British Aerospace Space Systems a contract for two communications satellites to be known as Skynet 4D and 4E for use by UK military forces. British Aerospace will be prime contractor to MOD with Matra Marconi Space Systems the major subcontractor for supplying the communications payload.

The launch of Skynet 4D, scheduled for 1997, will be from Cape Canaveral using a Delta II launcher and is intended to replace an on-orbit Skynet 4 satellite approaching the end of its operational life.

Laser Ground Station

A ground station with a 1-metre telescope to receive laser-optical signals from ESA's Artemis satellite, to be launched in 1997, is to be installed at the Telde Observatory, Tenerife, Canary Islands (see *Spaceflight*, January 1994, p.35).

On 29 April 1994, an agreement was signed between the Director of the Instituto de Astrofisica de Canarias (IAC), Prof Francisco Sanchez, and the Director General of ESA, Mr Jean-Marie Luton, which allows the IAC part-time use of the telescope for astrophysical research in exchange for making the site available to ESA. The site chosen for the deployment of the telescope is at 2400 metres altitude and the Optical Ground Station will be installed in the second half of 1995, awaiting the launch of ESA's telecommunications satellite Artemis and subsequent comprehensive tests with its SILEX laser-optical payload which will enable it to exchange data with other satellites by sending or receiving laser beams. (See ***Spaceflight***, May 1994, p.157).

Optical communications are a well-established technology on the ground. The first ever space link to make use of Artemis laser communications capabilities will involve the French Spot 4 satellite to be launched in early 1997.

French Space Budget

The French space agency is getting a 3.4% growth for its annual budget which now reaches 11 billion French Francs or nearly $2 billion for the year 1994. The French effort represents 40% of the total amount of government space funding by all European States.

France is giving top priority to national programmes but continues to contribute to ESA activities. Jean-Daniel Devi, Director General of CNES, explains: "For the time being, there is no special project which justifies a growing contribution of France to ESA. We look for establishing a strong bilateral relationship with Germany in order to develop a safe basis with equal partnership in the field of manned space systems".

In its 1994 space budget, CNES allocates a significant part to Ariane 5 development within the framework of ESA. It pushes ahead science programmes with USA, Russia, Japan, Italy and with ESA. The main growth in budget of CNES concerns activities in space applications - 7.9% of growth - covering Earth Observations (SPOT 4 development and SPOT 5 start), telecommunications, and search and rescue operations. A new programme of technological comsats will get the green light in the next months.

THEO PIRARD

Baikonur Cosmodrome

Russian Use Agreed for Next 20 Years

Agreement

Russia has made an historic agreement with the Republic of Kazakhstan for the management of operations at the Baikonur cosmodrome. The agreement was signed by the Presidents of the two countries in Moscow on 28 March.

For the next 20 years, Moscow will pay an annual fee of $115 million and in exchange Baikonur will remain Russian territory. THEO PIRARD

Proton Launch

On 4 April the first launch to follow the signing of the agreement took place.

Three satellites of the Glonass system (Cosmos-2275, -2276, -2277) were launched with a single three-stage Proton booster. The first similar satellites of the Glonass system (Cosmos-1413, -1414, -1415) were launched on 12 October 1982. The network of navigational satellites was thereafter built up with one or two launches a year, each of which took three spacecraft to space at the same time.

At present 12 Glonass satellites are operating in space, one of which is in reserve. The latest launch will add three satellites, making a total of 15. The system will be complete in 1995. The international organisations of civil and marine aviation (ICAO and IMO) have recognised the Glonass system, along with the analogous American navigation system Navstar, as basic for navigation of international air and sea routes. The system determines target coordinates to within 100 metres and speeds of 15 m/s.

Since the beginning of the space era on 4 October 1957, a total of 1,074 spacecraft have been launched from Baikonur.

Bulgaria and Russia

On 11 April the Bulgarian and Russian space agencies signed an agreement on cooperation in astro-navigation.

The five-year-long accord establishes a plan for joint research, including production of space-suits, space equipment and space food. The Deputy Administrator of the Russian Space Agency, Boris Ostroumov, was in Sofia for the 15th anniversary of the first Bulgarian-Russian joint space flight. On 10 April 1979, Bulgarian cosmonaut Georgi Ivanov and Russian Nikolai Rukavishnikov made the first joint space flight.

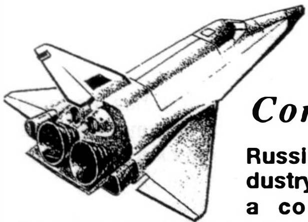
Russian Funding Problems

In the Russian manned programme the cosmonaut payroll is being dramatically reduced. Cosmonauts in general training for unspecified future missions are being struck off the list, but those already in training for specific missions will not be affected by the cutbacks.

Russian unmanned space programmes are also due to be cut according to the Deputy General Director of the Russian Space Agency, Yuri Milov.

Only three to four projects in each area will be supported from the current 22 communications satellite projects and the ten proposed Earth Observation systems. Almaz, which is an interesting and costly project, is in question as financing it would mean the end of other Earth observation programmes and the Mars programme can hardly be financed as well.

As for non-state funding, Russian commercial concerns do not want to invest in work that only brings benefits in several years time. A few commercial projects for communications satellites are all that Russia now has. The Space Agency is open to international cooperation but it has only three contracts to launch foreign satellites with Russian rockets. In other respects, satellites are equipped with foreign equipment, the exchange of satellite information is underway, flights of foreign cosmonauts on board the Mir station are profitable, as also is the leasing of satellite channels by foreign clients.



Space Industry Consortium

Russian space industry chiefs plan a consortium of Russian and Western investors to help the nation's cash-strapped space industry.

One of the projects likely to benefit from the plan is Russia's development of a revolutionary reusable orbiting spacecraft (MAKS). The craft can be launched into space from any location at any angle, unlike the US space shuttle. The 27-ton MAKS craft would be launched into space at an altitude of 10 km by a six-engine Mria carrier. The MAKS development programme was put on hold last December by the Russian government because of lack of funding.

"The Russian government is cutting back funds to the space industry", said Alexander Bashilov, General Director of the Molniya Science Production Association, which is setting up the consortium. "And we must therefore look to attract funds from commercial concerns both at home and abroad".

Proton Credit Deal

On 17 April the European Bank for Reconstruction and Development signed its first aerospace deal to provide stand-by credit to help a Russian rocket launch Western communications satellite.

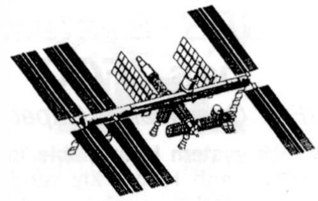
The $10.3 million facility will only be used in the case of non-performance by the rocket manufacturer Khrunichev, which is providing the Proton rocket for Inmarsat. The Inmarsat satellite should be launched in 1995 or 1996. A Proton rocket failed to launch a communications satellite into space on 27 May 1993 because of impurities in its fuel supply. Its last 20 launches have had a 95 percent success rate. Inmarsat approached the EBRD after the failure of talks with commercial banks on covering part of the risk. Khrunichev has been invited to tender for the launching of a second satellite.

Launch Lacks Money

Russia announced on 18 April that it lacked the money to launch its Electro-1, an advanced geostationary weather satellite, needed to complete a global meteorological network.

An official at the Russian weather monitoring service Rosgidromet said the Elektro satellite could have been launched last year had the money been available. The satellite is intended to hover above the Indian Ocean, covering territory from Germany in the west to Khabarovsk in the east and from northeastern Russia to Antarctica. Europe, the United States and Japan created an international system of geostationary satellites in 1977 which covers almost the entire world, but the Elektro satellite is needed to complete the coverage.

Space Station Defended



On 13 April, Daniel Goldin, Head of NASA spoke out against congressional critics who say that the space station programme costs too much and risks too much with Russian participation.

"NASA cannot handle the punishment that we're going through", he told a House of Representatives panel on space and technology, while speaking about the repeated budget cuts and constant criticism. "We have got to have stable funding and some kind of agreement about what we are going to do". He complained that a 30 per cent budget cut in the last 12 months had hampered the US space programme, including the redesigned space station. The space station has been a perennial target of budget-cutters in Congress and funding for the programme was only narrowly approved last year. Already $10.2 billion had been spent on the space station and he gave the figure of $17.9 billion as the estimate of how much more it would cost.

A general agreement for Russian components was signed in December 1993 and negotiators were now hammering out a detailed agreement for the purchase of Russian space hardware and support for the station. Asked whether reliance on Russian hardware would jeopardise safety in construction of the space station, Goldin pointed out that the Russians had many more hours in space than the US who had something to learn from them. NASA officials are nevertheless understood to be working out a contingency plan in case the US needs to act independently of its Russian partners while the space station is being built.

Papua New Guinea Telecommunications

Papua New Guinea is to join nearly 40 other countries whose domestic communications services are provided by INTELSAT.

Under a recently concluded agreement the transfer of Papua New Guinea's domestic telecommunications traffic from the Palapa satellite system to the INTELSAT system begins in September 1994. The move is designed to upgrade Papua New Guinea's immediate short-term capabilities and expand the country's long-term communications options. Initially operations will be in a 36 MHz global beam transponder on the INTELSAT 503 satellite at 183°E with an option to expand to two 36 MHz units in September 1995. In mid-1996, when the INTELSAT 701 satellite is available at 180°E, the network will move to this location, receiving greater power and coverage flexibility.

Space Centre Explosion

At least one person was killed and a $75 million weather satellite destroyed in an explosion at China's Xichang launch site on 2 April. More than 20 people were injured. Investigations into the cause of the blast are continuing. It was probably due to a leak in the on-board fuel system of the Fengyun 2 satellite. The status of six launches scheduled for later this year is not yet confirmed.

New Inmarsat Member

South Africa has become the 73rd member of Inmarsat and will be represented by Telekom SA as the country's signatory shareholder organisation. South Africa becomes the tenth African country to join Inmarsat. The others are Algeria, Camaroon, Egypt, Gabon, Liberia, Mauritius, Mozambique, Nigeria and Tunisia.

Belgian Astronaut Joins Belgacom

Dirk Frimout, who participated as a NASA payload specialist to the ATLAS-1 mission (STS-45) in March 1992 now leaves ESA to become research manager at Belgacom, the public operator of telecommunications in Belgium. He will be establishing and heading a new R&D department at Belgacom and will be specially concerned with the development of satellite systems for Belgium business in the field of international communications. He was an ESA scientist working for the Columbus programme on microgravity experiments at ESTEC in the Netherlands and also served as a space specialist in the Science Policy Office (SPO) of the Belgian government, a position which he also leaves. THEO PIRARD

Satellite Programmes Merge

On 10 May, it was announced that as a cost-cutting move US civilian and military environmental satellite programmes will be merged under a new Integrated Program Office.

US civilian and military weather satellite programmes are also to merge with NOAA (National Oceanic and Atmospheric Administration) assuming responsibility for operating the Defense Department's polar-orbiting weather satellites, as well as its own.

New Intelsat Member

On 7 April Brunei Darussalam joined Intelsat as its 132nd member nation when Mr Dato Malai Ali Malai Othman, Permanent Secretary, Brunei Ministry of Communication, signed the Intelsat Operating Agreement. The Ministry of Communication, as the Signatory designated by Brunei Darussalam, has an initial investment share of 0.05 per cent.

GPS System has 'FOC'

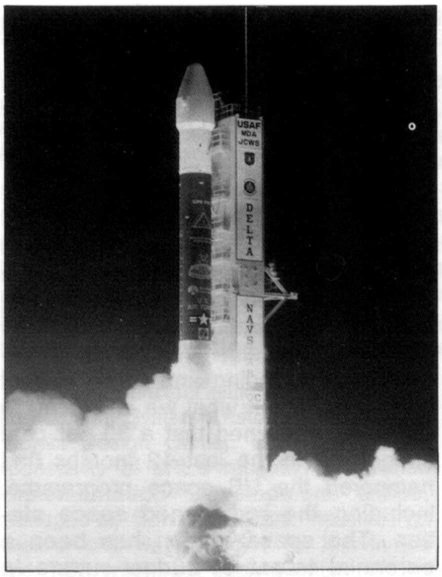
(Full Operational Capability)

The GPS system is available to anyone worldwide and is quickly rendering all other navigation systems obsolete.

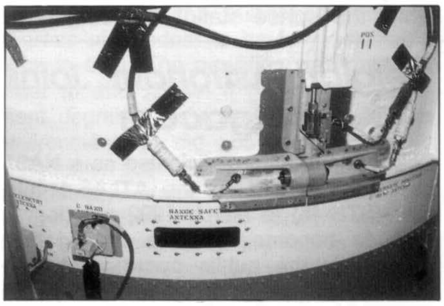
Aboard the Delta launched on 9 March was the final GPS satellite. Four spare satellites are in storage at Canaveral AF Station which could be launched within 60 days notice.

Attached to the Delta's upper stage was a NASA tether experiment called SEDS, which unreeled a 12 km 1/32 inch tether to test moving small masses to higher or lower orbits. After the successful test, 5 km of tether was broken off (by a suspected micrometeorite) but amazingly it remained visible for many nights as it traversed the sky. The long 1/32 inch tether is highly reflective and showed up as a line whose length was at least the diameter of the Moon. (with photos)

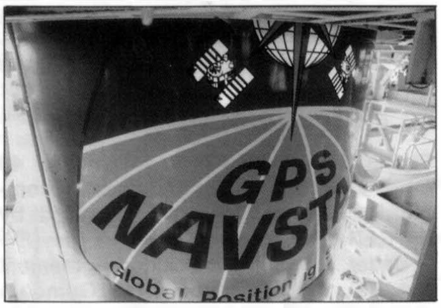
PETER GUALTIERI, WEST KENTUCKY NEWS)



A McDonnell Douglas Delta carries into orbit the final GPS (Global Positioning Satellite) of the 24 satellite NAVSTAR constellation on 9 March.



A close-up of the Range Safety Antenna which rings the rocket and is used to receive the 'destruct' signal from the Range Safety Officer should a failure occur in flight.



The mission logo on the side of the rocket is viewed at close quarters several days before the launch during a rare opportunity provided by the USAF to view an operational Delta.

Clementine

At 11:24 pm (EDT) on 3 May the Clementine spacecraft, which has been in lunar orbit for the last two months, was commanded to fire its rocket engine for four minutes to send it out of lunar orbit. On 7 May, a computer malfunction caused the spacecraft to burn fuel sending it spinning into an incorrect orbit. Attempts are currently being made to slow the spin and put it back on an orbit to loop back round the Earth and then fly within 100 km of the small asteroid 1620 Geographos on 31 August.

While orbiting the Moon, Clementine has mapped the lunar surface in unprecedented detail including the polar regions where interest centres on the possibility that ice deposited by comet impacts may be preserved in locations of permanent shadow.

The topography of 40 lunar basins has been mapped with a laser 'profiler' and found, in some cases, to be astonishingly deep. The Aitkin basin has a depth of 12 km, which is the record for the Solar System. Although Clementine has left the Moon, analysis of the large amounts of recorded lunar data is only just beginning.

Scout Era Ends

The 118th and final flight of a Scout space rocket took place at the Vandenberg Air Force Base at 7:47 pm PDT on 8 May. Scout is an all-solid propellant rocket that was first tested in 1960 and put into regular service in 1963 achieving a success rate of 98 per cent.

The rocket launched was also the last NASA-owned expendable launch vehicle. From now on, the agency will buy entire launch services from private contractors.

Indian Launch Success

The fourth development flight of India's Augmented Satellite Launch Vehicle (ASLV-D4) successfully took place on 4 May from the southern test centre of Sriharikota. A 113 kg satellite with two scientific payloads on board was placed in a low Earth orbit.

The ASLV programme is a forerunner of the PSLV (Polar Satellite Launch Vehicle), which is India's first space vehicle to use liquid-propulsion technology. The first PSLV launch in September 1993 failed to reach orbit (*Spaceflight*, November 1993, p.375).

Titan 4 Launches Spy Satellite

A Titan 4 rocket was successfully launched on 3 May from Cape Canaveral Air Force Station after three delays due to either technical problems or bad weather and nearly three years behind schedule due to problems with the launch pad and investigations into failures of two Centaurs and a Titan 4. No details of the payload have been officially released, but it is reported to be for electronic intelligence gathering and to be equipped with an extra large-sized antenna.

China Launches

After more than a year of negotiations, the China Great Wall Industry Corporation has signed a contract with Hughes Communications International Incorporated to launch the Optus B3 communications satellite aboard a Long March 2e rocket at the Xichang launch centre in the second half of this year.

The two sides also signed an agreement to launch an additional 10 Hughes-built communications satellites over the next 12 years. Hughes has some 60 percent of the worldwide commercial communications satellite market, with its products Asiasat-1 and an Australian-owned communications satellite already successfully launched by China.

DCX Tests

A restart of the test programme with the DCX experimental rocket is planned for June with three to five flights by the end of August.

Ariane Launch Operations Restart

Campaign operations for the launch of Flight 64 have now been scheduled in parallel with the final qualification tests that were introduced following the failure of Flight 63. The launch is currently programmed for late May - early June.

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-65	8 July	Columbia	13 Days	IML-2*	28.5
STS-68	August	Endeavour	9 Days	SRL-2	57.0
STS-66	September	Atlantis	10 Days	Atlas-3, Crista-SPAS, SSBUV/A	57.0
STS-64	September	Discovery	9 Days	LITE, GBA	57.0
STS-63	January	Discovery	8 Days	Spacehab-3, Spartan-204, CGP/Oderacs-2	51.6
STS-67	January	Endeavour	13 Days	ASTRO-2	28.5

*Japan's first woman astronaut, Chiaki Mukai, will be a member of the crew.

Space Shuttle Columbia lifts-off from Pad 39B at 8:53:07 am (EST) on 4 March 1994. NASA

Two Weeks of In-Orbit Research and Experimentation

Following a one-day postponement for weather, Columbia was launched on its sixteenth space flight at 8:53 am on 4 March 1994. The major focus of the mission was on technology and materials sciences experiments.

Extended Duration Orbiter

STS-62 was the third extended duration orbiter (EDO) mission for Columbia. STS-50 in 1990, lasting over 13 days 19 hours, together with STS-58 in 1994, lasting 14 days and 12 hours, were the previous two EDO missions. During an EDO mission a special structure containing additional fuel cell reactants is mounted at the aft end of the payload bay in order to provide electrical power for the additional time in space. The 15-foot-diameter structure weighs approximately 3,500 pounds empty and supplements Columbia's five hydrogen and oxygen reactant tanks. Fully loaded, the structure contains an additional 368 pounds of liquid hydrogen at -418 degrees Fahrenheit and 3,125 pounds of liquid oxygen at -285 degrees Fahrenheit. The system provides sufficient power for up to a 16-day mission with an additional two contingency days.

An aim of the STS-62 extended mission was to assess the impact of space flights of more than ten days on astronaut health, identify any operational medical concerns, and to test countermeasures for the adverse effects of weightlessness on the human physiology. The Medical Sciences Division of the Johnson Space Center sponsored 11 additional investigations - termed Detailed Supplementary Objectives (DSO) - for both flight and postflight studies.

Prelaunch Processing

Columbia began its STS-62 processing at KSC's Orbiter Processing Facility (OPF) bay 2 in November 1993. Following its landing at Edwards Air Force Base at the completion of STS-58, Columbia was returned to KSC on November 8 and remained in the OPF until 3 February 1994, when it was moved to the Vehicle Assembly Building for mating with the External Tank and Solid Rocket Boosters. The Shuttle was then moved to launch Complex 39B on 10 February.

While in the OPF the orbiter's STS-62 engines were installed beginning on 10 January. The STS-62 engines were serial #2031 in the number one (upper) position with nine previous flights and 7,121 seconds of hot-fire time (STS-62 would bring the engine to over two hours of firing time); #2109 in the number two (lower left) position with two previous flights and 1,888 seconds of hot-fire time, and #2029 in the number three (lower right) position with five previous flights and 6,068 seconds of hot-fire time.

Payloads which were to be mounted in the payload bay wall were installed and tested in the OPF, whereas cross-bay payloads were installed at the launch pad. A two-day simulated countdown was then performed during the final hours of which the flight crew entered the cabin and performed as they would on the launch day.

Countdown

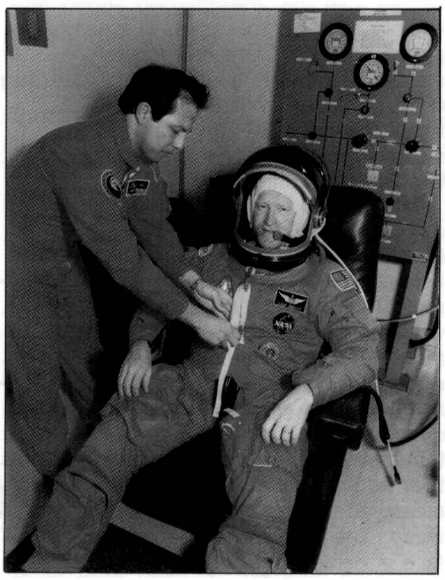
As the countdown was proceeding however, concern arose as weather projections for the launch on 3 March reached 90 percent "no-go" conditions. Managers waited until the mid-day weather update and found that the actual approaching weather conditions were following closely those predicted and decided at that point to remain in the T-11 hour hold for 24 additional hours and go for a launch on 4 March.

The day dawned clear and sunny and the countdown progressed with no unforeseen delays. The crew arrived at the orbiter about 6:00 am and the cabin hatch was closed by 7:30 am. The Ground Launch Sequencer computers took over control of the countdown at T-9 minutes. The countdown continued with power being transferred from the ground to the orbiter's system at minus 50 seconds and at T-31 seconds the "go for auto sequence start" command was sent to the orbiter computers. At minus 6.6 seconds main engine three start was initiated, followed by main engine two at minus 6.48 seconds and main engine one at minus 6.36 seconds. With three engines up and running normally at 100 percent power and all systems performing as planned STS-62 lifted off from Launch Complex 39B on time at 8:53 am on 4 March 1994.

Into Orbit

At launch plus 10 seconds STS-62 began an eight second roll manoeuvre, bringing the orbiter to a heads-down position as it arced across the Atlantic. The main engine began to throttle down to 67 percent at T+32 seconds to reduce aerodynamic loads. Max Q, maximum dynamic pressure was reached at plus 51 seconds, followed by throttle up to 104 percent for the main engines. The Solid Rocket Boosters completed their task and were separated from Columbia at 2 minutes 6 seconds. Main engine cutoff came at 8 minutes 36 seconds. At 45 minutes after launch the orbiter manoeuvring engines completed an approximately 2 minute 12 seconds firing and STS-62 was in a 160 by 163 nautical mile 39 degree inclination orbit.

Sam Gemar dons his launch/entry suit in the Operations and Checkout Building with assistance from a suit technician. NASA



STS-62 Payloads

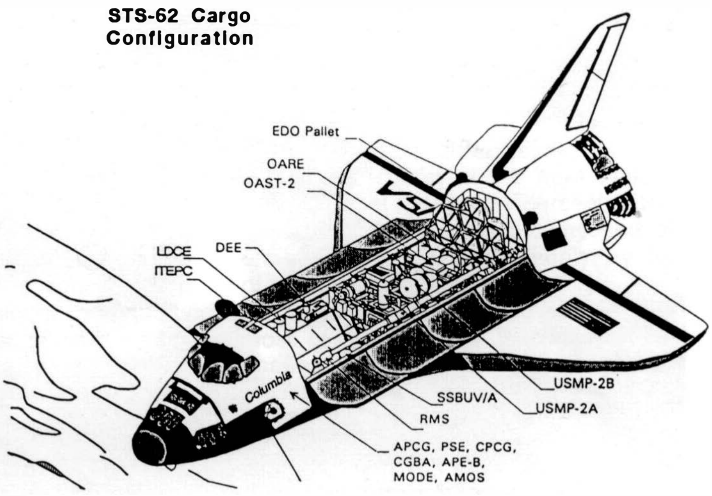
USMP-2

The United States Microgravity Payload-Two (USMP-2) is one of a series of payloads designed for scientific experimentation and materials processing in the microgravity environment of the Space Shuttle orbiter's payload bay. USMP-1 flew on STS-52 in October 1992.

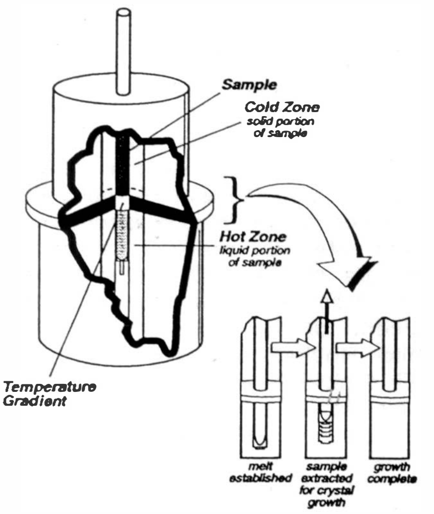
USMP-2 consists of four microgravity experiments and an accelerometer, mounted on two Mission Peculiar Experiment Support Structure (MPESS) cross-bay trusses together with the supporting systems for the USMP-2.

USMP-2's experiments include the Advanced Automated Directional Solidification Furnace (AADSF), Materials for the Study of Interesting Phenomena of Solidification on Earth and in Orbit (MEPHISTO, acronym is in French), the Isothermal Dendritic Growth Experiment (IDGE) and the Critical Fluid Light Scattering Experiment (CFLSE/Zeno).

STS-62 Cargo Configuration



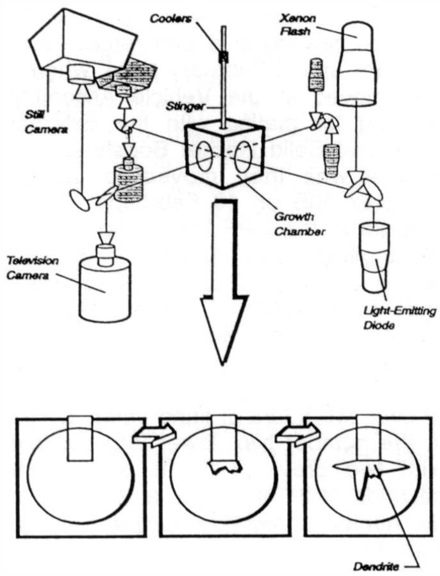
AADSF investigates the effect of gravity on the directional solidification of semiconductor material, which on STS-62 was cadmium telluride. The experiment consists of the Furnace Container, Signal Conditioning and Control System and the Data Acquisition System. The Furnace Container houses a multizone furnace which moves a sample through three controllable furnace temperature zones, such that a complete temperature profile can be established along the sample as it is processed. The sample is grown at a slow rate of approximately 0.7 mm per hour and produces a crystal that allows testing of theories about the uniformity and properties of such crystals after solidification.



AADSF Experiment. NASA

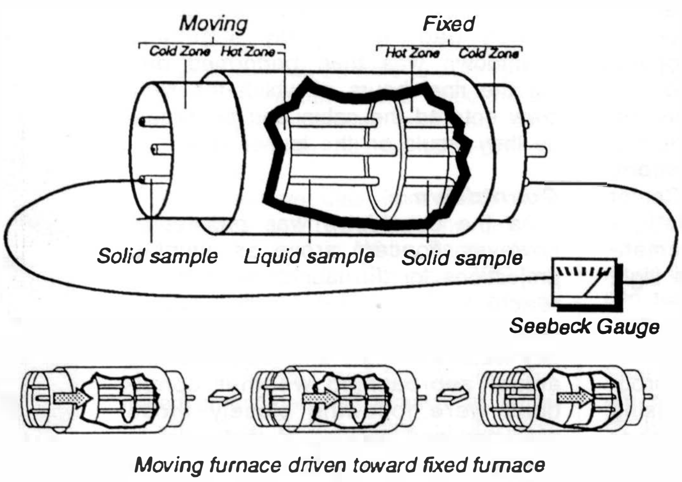
MEPHISTO, which also flew on USMP-1, processes three identical cylindrical samples using a fixed and moving furnace. The fixed furnace provides a stationary solid/liquid interface that is used as a reference for electrical measurements. As the moving furnace is driven toward the fixed furnace, the temperature fluctuations of the liquid/solid interface are measured by the Seebeck technique. The position of the interface is determined by the electrical resistance technique and is marked at intervals with an electric current pulse. The sample is returned to Earth for analysis.

The IDGE studies solidification of materials also, but on a different scale. Dendrites are tiny crystalline forms that develop as materials solidify under certain conditions. On STS-62 the growth chamber was filled with ultra-pure succinonitrile and used a "stinger" to begin the dendrite growth. As the stinger cools, the material solidified to begin the development of a dendrite. Images of the dendrite growth phases were transmitted to the science team on the ground.

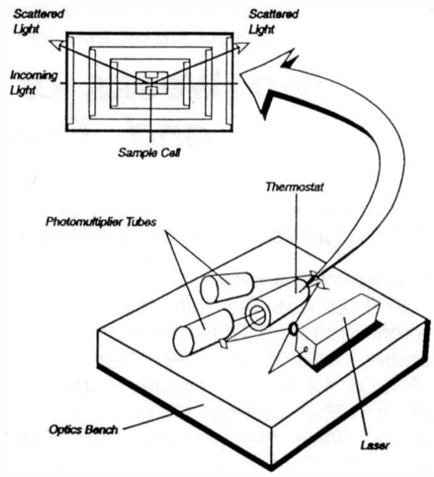


IDGE Experiment. NASA

MEPHISTO Experiment. NASA



The CFLSE/Zeno experiment studies the behaviour of xenon at its critical point, i.e. the temperature and pressure where xenon exist as liquid and as gas simultaneously. Studying the critical point of materials on Earth is difficult due to the effects of gravity. The experiment is housed in two modules on the USMP-2. The Optics Module contains the laser optics, the sample, and the detectors which capture the scattered laser light. The Electronics Module contains the controlling electronics, computers, and circuitry. After the optics are allowed to stabilise, the experiment searches for the critical temperature of the sample. After determining the critical temperature a series of light scattering measurements are made at temperatures closer and closer to the critical temperature.



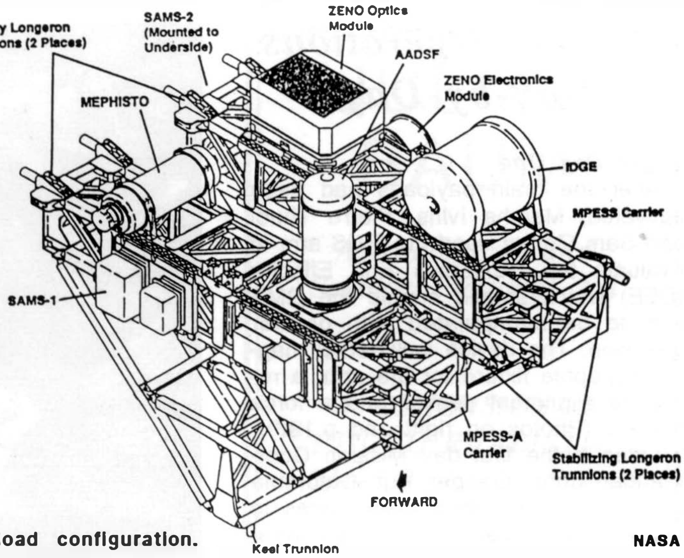
ZENO Experiment. NASA

The USMP-2 accelerometer was the Space Acceleration measurement System (SAMS) which has flown previously on other Shuttle emissions. SAMS monitors and records accelerations and vibrations experienced during the flight.

OAST-2

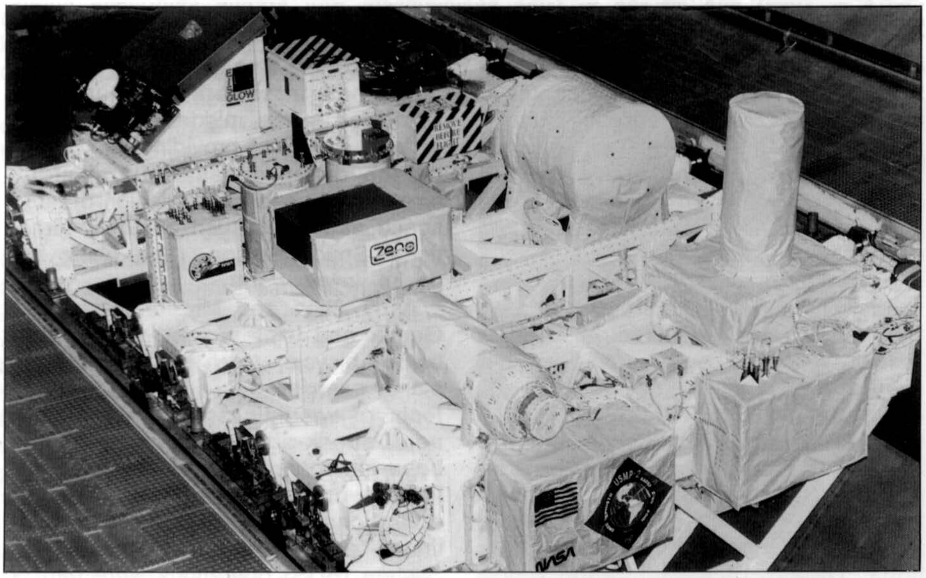
The second major payload to fly on the STS-62 mission was the Office of Aeronautics and Space Technology-Two (OAST-2). OAST-2 is a collection of several experiments. The objective of OAST-2 is to obtain technology data to support future development of satellites, sensors, microcircuits and the International Space Station.

OAST-2 carries its experiments mounted upon a single cross-bay mounted MPESS which uses the Goddard Space Flight Center's Hitchhiker program subsystems. The experiments include the Emulsion Chamber Technology (ECT), Experimental Investigation of Spacecraft Glow/Spacecraft Kinetic Infrared Test (EISG/SKIRT), Thermal Energy Storage (TES), Solar Array Module Plasma Interaction Experiment (SAMPIE), and Cryogenic Two-Phase Experiment (CRYOTP) experiments.



Payload configuration. NASA

The ECT consists of an emulsion chamber container and an electronics unit and collects data on radiation in space using photographic plates rather than sensors. The ECT is made up of a stack of photographic plates, X-ray film, lead plates and polycarbonate resin. Radiation particles passing through the stack leave tracks that can later be measured. The experiment is designed to provide better data for future shielding requirements.


STS-62 payload before closeout at the Operations and Checkout Building at KSC.
P. QUALTIERI/WEST KENTUCKY NEWS

EISG/SKIRT consists of two separate assemblies that measure spacecraft glow intensities as a function of temperature. Spacecraft glow occurs when a rapidly moving object collides with atoms of oxygen and nitrogen in low Earth orbit, causing light emission. As the orbiter passes in and out of darkness and sunlight during its orbit, its surface temperature changes, thereby affecting the light emitted by the atomic particles.

TES investigates the formation of voids during the cooling of two different thermal storage salts contained inside two GAS canisters. The lithium fluoride and fluoride eutectic test materials absorb heat, melt and expand in volume. Upon cooling, the samples contract and form voids. Repeated cycles of heating and cooling allow this effect to be studied and provide data for the future design of spacecraft solar dynamic thermal systems.

SAMPIE studies the interaction between a spacecraft and the widely scattered plasma of oxygen and nitrogen ions in low Earth orbit, which could potentially interact with the higher operating voltages present in satellites and launch vehicles. SAMPIE performs six individual experiments; each with a different spacecraft material, for potential interactions. SAMPIE also contains two electrical probes which monitor the plasma. The data should provide information for the design of improved solar cell and high voltage spacecraft equipment.

The CRYOTP experiment measures the microgravity performance of a liquid nitrogen heat pipe and a thermal storage unit based on solid-liquid phase change material. The experiment is designed to provide information on heat dissipation in spacecraft since the sensors and electronics in today's spacecraft generate considerable quantities of heat.

Additional smaller payloads mounted on Columbia's payload bay walls were the Limited Duration Space Environment Candidate Material Exposure (LDCE) and the Dexterous End Effector (DEE) experiments mounted on the starboard payload bay wall; together with the Shuttle Solar Backscatter Ultraviolet (SSBUV) payload which was mounted on the port payload bay wall.

The LDCE introduces composite materials to a flux of atomic oxygen in the low Earth orbit. The candidate materials, including polymeric, coated polymeric, and light metallic composite materials, had undergone extensive ground testing prior to flight. The experiment exposed three sets of materials, each comprised of 264 samples. Each set was contained in its own containers and the containers were opened on-orbit to expose the sample materials.

The DEE uses powerful electromagnets with an attraction force of 3,200 pounds to grapple objects with the robot arm in Columbia's payload bay. Its task is to demonstrate advanced teleoperator operations on-orbit. The DEE uses a specially designed end effector called a Magnetic Attachment Tool (MAT) that is grappled by the robot arm standard end effector via an electrical flight grapple fixture. The MAT uses electromagnetic grappling, in combination with a force torque sensor, to perform experimental tasks with a task bar. Additionally, a new Targeting and Reflective Alignment Concept is used to optically align the end effector relative to a target in six independent axes. Postflight data analysis is performed using televised images, video cassette recordings and the Payload General Support Computer data recording.

The SSBUV on STS-62 was the sixth flight of the instrument. The SSBUV provides highly accurate measurements of atmospheric ozone for direct comparisons with similar ozone detectors on US and Russian satellites to verify the accuracy of the readings provided by such satellites. The instrument is laboratory-calibrated before and after flight to provide precise standards by which to verify the satellite data.

In addition to its payload bay experiment complement, Columbia also carried several experiments in its middeck area which were operated by the flight crew. These included the Advanced Protein Crystal Growth (APCG), Physiological Systems Experiment (PSE), Commercial Protein Crystal Growth (CPCG), Commercial Generic Bioprocessing Apparatus (GCBA), Middeck O-Gravity Dynamics Experiment (MODE) and Bioreactor Demonstration Systems (BDS).

Mission Operations Day-by-Day

Pierre J. Thuot and Marsha S. Ivins communicate with ground controllers during operations and observations with the Dexterous End Effector (DEE). NASA

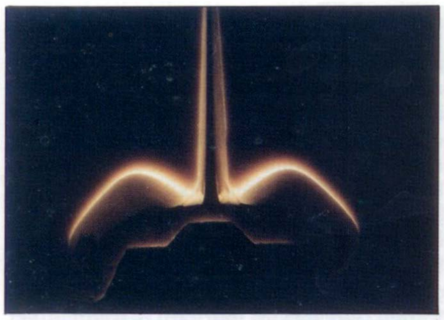
Flight Day One

After the main payloads had been activated, Marsha Ivins, Pierre Thuot and Sam Gemar used the RMS arm to evaluate the Dexterous End Effector (DEE) which should enable the RMS arm to be manipulated with greater precision. The device included a magnetic grapple fixture for the arm, a reflective alignment sensor and a force sensor. (Photos on right and p.193).

Later in the first day Mission Commander John Casper put Columbia through several rolling manoeuvres to calibrate the Spacecraft Kinetic Infrared Test (SKIRT) experiment on OAST-2. As the mission progressed SKIRT studied the glow effects as Columbia encountered atomic oxygen in low Earth orbit. (See following photo).

Flight Day Two

Mission Specialist Sam Gemar and Pilot Andy Allen took turns in the Lower Body Negative Pressure (LBNP) unit, a device which simulates gravity's effect on body fluids by pulling body fluids into the lower extremities (see photo below). In microgravity, body fluids pool in the upper extremities and the LBNP experiment simulated the sudden return to gravity experienced at the end of Shuttle missions. Longer sessions took place later in the flight.



The glow phenomenon surrounding the vertical stabiliser and orbital manoeuvring system (OMS) pods of Columbia during a night pass. NASA

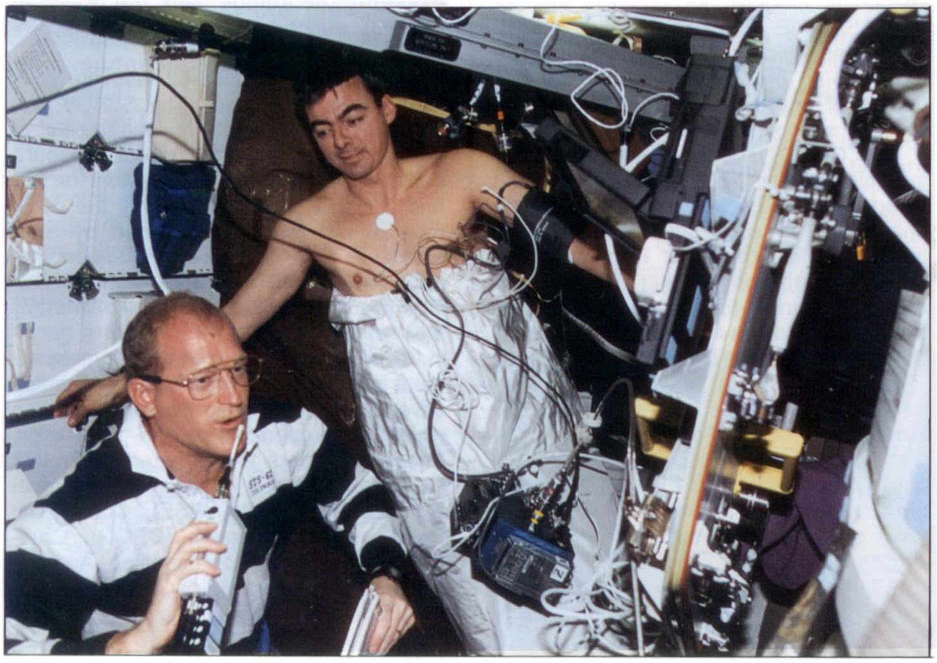
Payload controllers at the Goddard Space Flight Center reported that the OAST-2 payload's experiments were working well with the CRYOTP experiment operating for ten hours. USMP-2 operations included the MEPHISTO solid/liquid interface experiment, AADSF direction solidification experiment, ZENO critical fluid light scattering unit, IDG dendritic growth studies, and SAMS accelerometer observations. Details of experimental payloads appear on pp.188-189.

Flight Day Three

A small trusswork structure was fabricated in the middeck for a series of tests aimed at providing information on the dynamic behaviour of structures to be used in the design of large space structures such as the International Space Station. (See photo opposite lower right).

Andy Allen and Mission Specialists Gemar and Ivins took turns on a stationary bicycle, which has long been a staple exercise item to reduce the effects of weightlessness; however, a new shock-absorbing system has been incorporated to reduce the unit's impact on microgravity experiment operations. USMP-2 operations continued and Bioreactor Demonstration System (BDS) operations were part of the day's schedule.

Sam Gemar talks to ground controllers while assisting Andy Allen during his turn in the Lower Body Negative Pressure (LBNP) apparatus. NASA



Flight Day Four

The crew set up the model trusswork structure to float free in the middeck area as its behaviour was recorded and analysed to determine how large structures behave in microgravity.

Experiments with the LDCE limited duration materials study, USMP-2, OAST-2, and SSBUV continued around the clock. Much of the control of these experiments was from the ground. SSBUV had been operating since the first day of the flight and its controllers were planning to detect sulphur dioxide emissions from volcanoes in Central America to determine if such emissions were detectable from low Earth orbit.

The crew performed checks of the protein crystal growth experiments and of the rodents housed in the middeck as part of the Physiological Systems Experiment (PSE).

Later in the day Andy Allen and Sam Gemar had a half-day off, as did each of their crewmates the following day.

Flight controllers wanted to schedule some time off during the long duration flight so that the astronauts could continue to perform at peak levels through the mission.

Flight Day Five

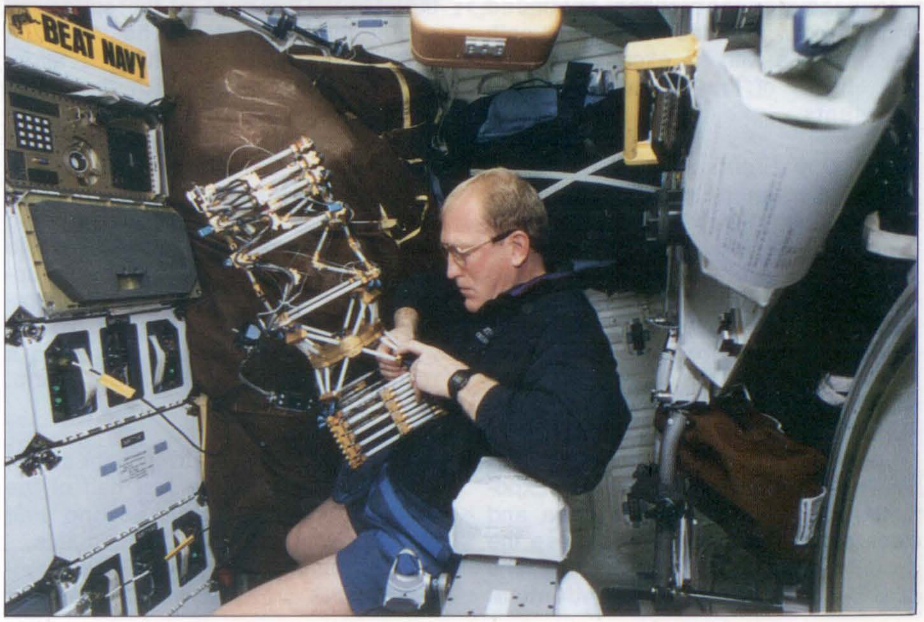
Ground based researchers continued to remotely operate experiments in Columbia's payload bay. The SSBUV continued its observations and recorded data on the layers of the Earth's atmosphere, tropospheric emissions from Central American volcanoes, and sulphur dioxide from industrial byproducts above China and Japan, as well as mesospheric observations above the Mexican Volcano Colima.

The OAST-2 SAMPIE experiment exposed materials being developed for future spacecraft to the orbital environment. The experiment included the operation of an advanced solar energy cell as well as plasma interactions with various materials as the orbiter's payload bay was pointed toward Earth. OAST-2 operations also included ten freeze and thaw cycles of a thermal energy experiment studying cooling technology for future spacecraft; spectrometer readings of the upper atmosphere by the EISG Shuttle glow instrument; and SKIRT instrument studies of the Shuttle orbiter's interaction with atomic oxygen.

Above: The official STS-62 crew picture. Standing left to right are Charles D. (Sam) Gemar, Marsha S. Ivins and Pierre J. Thuot, seated left to right are Andrew M. Allen and John H. Casper. NASA

Left: Marsha S. Ivins, prepares to aim three Hasselblad cameras through the overhead window of the orbiter. The three cameras were allowed to simultaneously record the same imagery on different types of film for purposes of comparison and experimentation. NASA

Below: Sam Gemar works with the middeck O-gravity dynamics experiment (MODE) aboard the orbiter. As depicted here, the reusable test facility is being used to study the nonlinear, gravity-dependent behaviour of large space structures planned for future spacecraft. NASA



Flight Day Six

Activities in the payload bay included observation of cloud tops with the SSBUV instrument in an attempt to understand how clouds affect satellite observations. Studies were also made of UV light reflected from the Earth's atmosphere above the deserts of North Africa and Saudi Arabia in order to gather information on how UV reflections differ over various areas of the Earth.

The three bright patches in the centre of the photo are the cities of Springfield, Dayton and Cincinnati. Lake Erie, Cleveland and Akron are in the upper left quadrant. Louisville and New Albany are in the lower right corner and Indianapolis is in the lower left. NASA

The OAST-2 payload continued its investigations of the glow effect around the orbiter caused by contact with atomic gases. OAST-2 also continued studies of supercooling technology by use of cryogenic gases and heat pipes.

The Columbia's crew took time out to salute the 60th anniversary of the birth of Russian cosmonaut Yuri Gagarin who became the first person to fly in space on 12 April 1961. Gagarin, born on 9 March 1934, died in a plane crash in 1968.

Flight Day Seven

Andy Allen, who had been launched on STS-62 as a United States Marine Corps Major, was advised by Mission Commander Casper that he had received his promotion to Lieutenant Colonel, effective immediately. He celebrated his promotion by receiving temporary oak leaves and congratulations from his four fellow astronauts. The crew assembled for a short ceremony before resuming engineering and medical experiments.

Payload bay operations continued and the crew rounded off their seventh day in space with an exercise session and checks of the crystal growth experiments.

Flight Day Eight

The mission passed its half-way point and for the first time since the initial day of the mission Columbia changed its orbital attitude and was now orbiting with its tail pointed toward the Earth and the open payload bay pointed in the direction of travel - termed the "ram" direction. The previous attitude had the payload bay toward the Earth.

Casper utilised the Long Duration Space Environment Candidate Exposure (LDCE) experiment to open and close sample containers to expose the experiment's samples to space. The LDCE consisted of three identical sample plates with 264 samples of various materials used in space vehicles. One set was exposed during most of the mission, one set exposed during only ram type attitudes, and the third when the orbiter was not in a ram attitude.

Flight Day Nine

Commander John Casper and Pilot Andy Allen worked with PILOT (Portable Inflight Landing Operations Trainer) which is a laptop computer with landing simulation software and a rotational hand controller. PILOT allows practice of simulated landings at the KSC Shuttle Landing facility and is undergoing tests to evaluate its suitability for maintaining astronauts' proficiency during extended duration missions.

During Columbia's 125th orbit the spacecraft passed directly over the eye of a cyclone in the Indian Ocean and crewmembers photographed the storm.

After turning in for the night, the crew were awakened when one of the small thrusters in the nose of the space got colder than expected. The condition was remedied by inputting a slight pitching of the nose which developed more drag causing the thruster to fire more frequently and thereby keep itself warmer. The orbiter's 'tail toward the Earth orientation' placed the least amount of residual atmospheric drag on the spacecraft and therefore led to less frequent thruster firings in support of the USMP-2 experiment operations. The slight pitch change did not affect data gathering but prevented a recurrence of the cold thruster alarm.

Flight Day Ten

The crew had a relatively light day of work as they took the first half of the day off and spent the second half working with middeck experiments.

Later during an in-flight news conference the crew answered questions ranging from budget cutbacks and safety to experimentation and life on the planned International Space Station.

Flight Day Eleven

Payload bay science operations shifted their focus from the USMP-2 microgravity studies to the interaction of the orbiter with atomic oxygen, nitrogen and other residual gases in orbit as the OAST-2 instruments became the major payload bay activity.

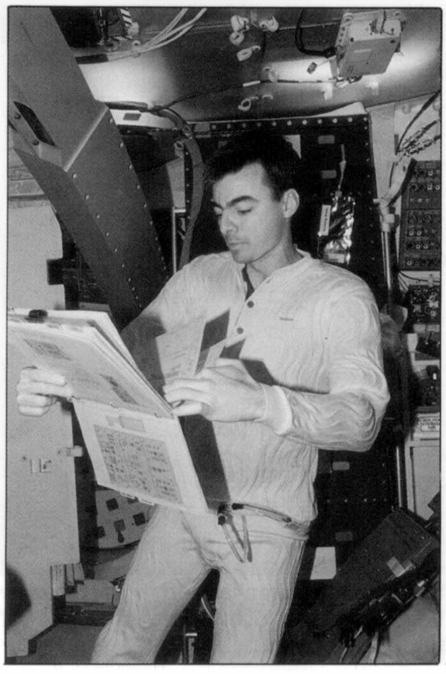
Columbia's manoeuvring engines were fired twice to descend from a 161 by 157 nautical mile orbit to a circular orbit at 140 nautical miles altitude. Shortly thereafter the OAST-2 payload performed a three-minute release of nitrogen gas from a canister for studies of its effect on a special plate which was constructed of sample materials that may be used in the construction of future spacecraft. An unanticipated result was the extinguishing of the glow by the nitrogen release.

Later, with its tail toward the Earth, Columbia performed a series of 360 degree spins to allow observations by the OAST-2's SKIRT instrument. During the manoeuvring the crew were able to take SSBUV observations of the Sun for comparison with previous SSBUV mission observations.

Flight Day Twelve

Columbia's crew spent much of the day evaluating new technologies for use in support of RMS operations. Marsha Ivins, Pierre Thuot and Sam Gemar took turns operating the arm to continue experiments with the DEE equipment. The crew's tests utilised

Andrew Allen is attired in a new thermally controlled undergarment. As part of a detailed test, both Allen and John H. Casper wore the undergarments during launch and entry phases of flight. NASA



the fifty foot long arm to insert pins into sockets that had progressively smaller clearances, ranging from 12/100th of an inch to 3/100ths of an inch. Later, a foot-wide flat beam was inserted into a slot and moved to correlate readings by the DEE's force sensor.

Flight Day Thirteen

Preparations began for landing with a standard check of the flight control systems that Columbia would use for reentry and landing. After the check-out, the crew fired Columbia's orbital manoeuvring engines for 38 seconds to change the spacecraft's orbit to support further glow experiments.

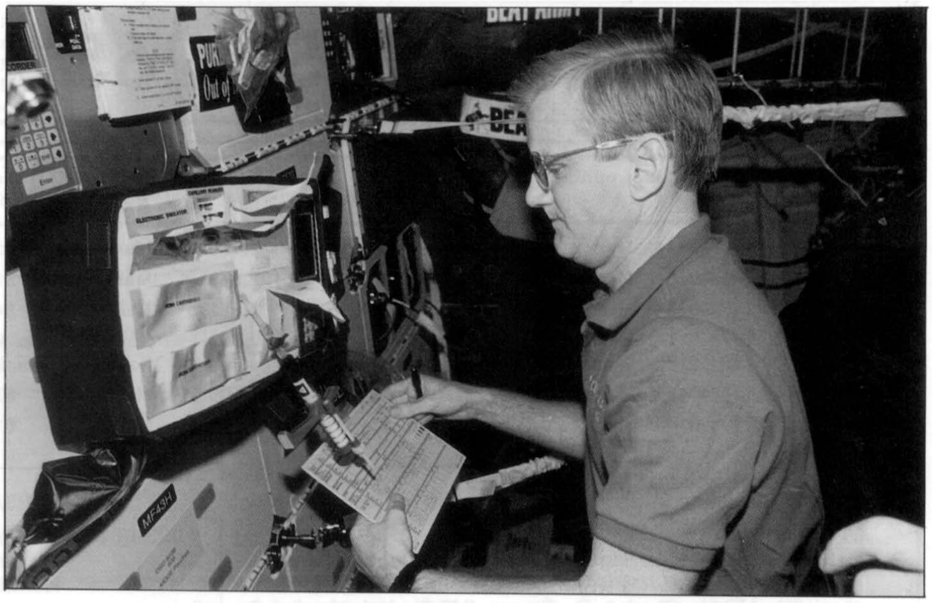
Columbia's new orbit had an apogee of 140 nautical miles and a perigee of 105 nautical miles. This was the lowest sustained orbital altitude of any Shuttle flight to date. The crew noted that the sensation of "speed" was much greater at Columbia's lower orbital point, and they also noted how well the Earth could be seen from that altitude. At the lower altitude the glow effect was much more pronounced.

Flight Day Fourteen

The five astronauts performed final checks of their spacecraft and began stowing equipment in preparation for their scheduled landing. Columbia's 38 primary thrusters were fired early in the morning and all functioned normally. Later, Casper and Allen practised simulated Shuttle landings using the PILOT laptop computer-operated system.

Sam Gemar spent four hours in the LBNP to continue studies on body fluid reactions to microgravity and Marsha Ivins powered down the RMS robot arm and latched it into its cradle. Pierre Thuot closed down the two protein crystal growth experiments.

The new computer file unit, being operated for the first time on STS-62, had operated for 86 minutes over the course of the mission and the crew had been able to downlink 283 files containing documents, graphics, digitised photographs, and video. It would have taken the orbiter's standard 2400 baud computer modem system 3 days and 22 hours to transfer the same amount of data.



John S. Casper takes stock of paraphenalia used to support medical testing. NASA

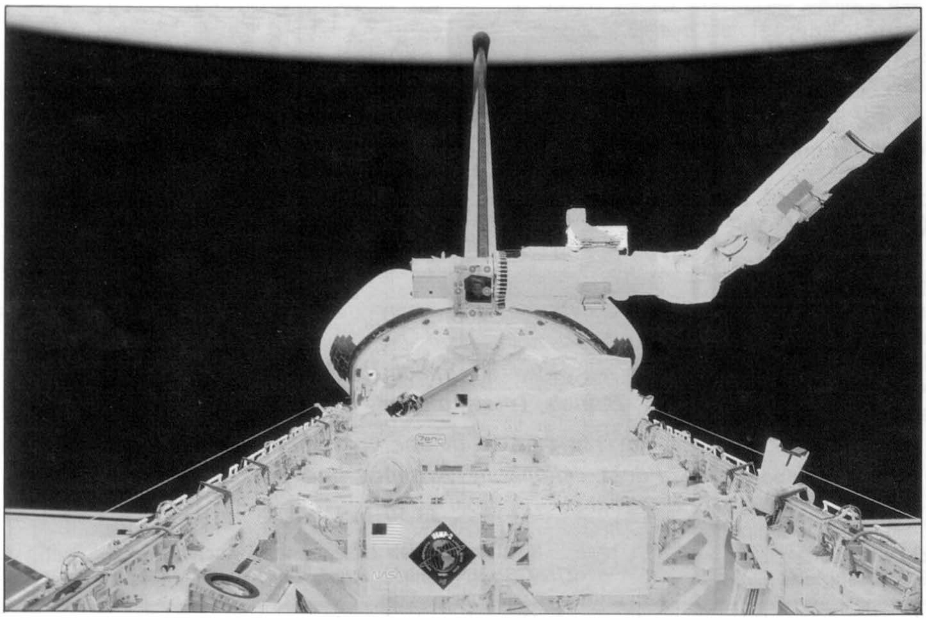
Flight Day Fifteen

After awakening at 10:53 pm on 17 March the crew completed their final stowage operations and configured the orbiter for landing. The payload bay doors were closed and the orbiter fired its manoeuvring engines at approximately 7:18 am on Friday, 18 March.

The reentry took the orbiter over predawn northern California where it was clearly visible from the ground and was followed by a normal approach to the Kennedy Space Center.

Main landing gear touched down at 8:09:41 am, nose gear touchdown came at 8:10:00 am and wheel stop was at 8:10:35 am. The 13 day, 23 hour, 17 minute and 35 second long mission was the second longest flight in the Space Shuttle Program. STS-55, Columbia's October 1993 mission, lasted a little less than an hour longer than STS-62.

A 70 mm photograph taken through the aft flight deck windows of the orbiter during activity with the Dexterous End Effector (DEE). NASA



About the Crew

Mission Commander was ***John H. Casper***, 50, Col., USAF, who was making his third Shuttle space flight. He became an astronaut in 1984 and flew as Pilot on STS-36 in 1990 and as Commander on STS-54 in 1993. Prior to STS-62, he had over 250 hours in space.

Mission Pilot was ***Andrew M. Allen***, 38, Major, USMC, who was making his second space flight, having served as Pilot on STS-46 in 1992. He was selected for astronaut training by NASA in 1987 and had over 191 hours of space flight experience before the STS-62 flight.

Pierre J. Thuot, 38, Cmdr., USN was Mission Specialist-One. He was selected as an astronaut in 1985 and had flown twice previously as Mission Specialist on STS-36 in 1990 and again aboard STS-49 in 1992. He had over 319 hours of space flight experience, including almost 18 hours of EVA, prior to STS-62.

Charles D. (Sam) Gemar, 38, Lt. Col., USA was Mission Specialist-Two for the flight. A 1985 NASA astronaut selectee, he was making his third space flight, having flown previously as Mission Specialist on STS-38 in 1990 and STS-48 in 1991. He had over 245 hours of space flight before this mission.

Mission Specialist-Three was ***Marsha S. Ivins***, 42, who was selected for astronaut training in 1984. STS-62 was her third space flight, having flown previously as Mission Specialist on STS-32 in 1990 and STS-46 in 1992. She had over 452 hours of space flight experience before STS-62. ■

SATELLITE DIGEST-265

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Coronas-I	1994-014A	Mar 2.14	Plesetsk	Tsyklon	2,160	Mar 2.92	82.49	94.78	487	528	[1]
Columbia	1994-015A	Mar 4.58	KSC	Shuttle	102,860	Mar 4.64	39.01	90.54	297	305	[2]
Navstar 24	1994-016A	Mar 10.15	ER	Delta-2	1,881	Mar 15.23	54.92	714.56	19,927	20,268	[3]
STEP-0/P90-5	1994-017A	Mar 13.94	WR	Taurus	503	No orbital data issued					[4]
DARPASAT	1994-017B				200 ?	No orbital data issued					[4]
Cosmos 2274	1994-018A	Mar 17.69	Plesetsk	Soyuz	6,500 ?	Mar 17.80	67.13	89.64	163	350	[5]
Progress-M 22	1994-019A	Mar 22.20	Tyuratam	Soyuz	7,250 ?	Mar 22.44	51.64	90.24	255	318	[6]

NOTES

1. Science payload, investigating interaction of solar activity with near-Earth space.
2. STS-62 mission, carrying five astronauts: John H. Casper (commander), Andrew M. Allen (pilot), Pierre J. Thuot (mission specialist, MS-1), Charles D. Gemar (MS-2) and Marsha S. Ivins (MS-3). Payload bay included USMP-2 (United States Microgravity Package, 4,357 kg) and OAST-2 (Office of Aeronautics and Space Technology, 2,626 kg). Landed at Edwards Air Force Base 1994 March 18.55
3. Also called USA 100, launch completes NAVSTAR/GPS operational constellation.
4. Maiden flight of Taurus launch vehicle, carrying two classified payloads carrying out various advanced technology experiments. No orbital data issued via USSPACECOM, but launch announcement gave 105°, 540-555 km - implying an orbital period of 95.59 minutes.
5. Fourth generation, close look photoreconnaissance satellite in the Yantar series.
6. Cargo freighter, docked with Mir Complex 1994 March 24.15.

ADDITIONS AND UPDATES

1993-019A Progress-M 17 decayed from orbit 1994 March 2-3.

1993-061C USSPACECOM originally catalogued this object as Uribyol 2 (KITSAT B) but has now identified it as EYESAT A.

1993-061D USSPACECOM originally catalogued this object as POSAT 1 but has now identified it as ITAMSAT.

1993-061G USSPACECOM originally catalogued this object as EYESAT A but has now identified it as POSAT 1.

1993-061H USSPACECOM originally catalogued this object as the Ariane launch vehicle's third stage but has now identified it as Uribyol 2 (KITSAT B).

1993-075A The data for the landing time for Endeavour/STS-61 are in error by 12 hours. The descent date should be 1993 December 13.23.

1993-076 The launch time should be 1993 December 8.03 (00.48 GMT).

1993-076A NATO 4B has now reached its planned geosynchronous orbit location over 5 °E. Add the following orbit: 1994 March 16.70, 4.02°, 1,436.13 minutes, 35,785 km, 35,790 km.

1993-079A The orbit of Molniya-1 87 was finally stabilised during 1994 March 19-21. Add the following orbital data: 1994 March 21.02, 62.90°, 717.04 minutes, 471 km, 39,848 km.

1994-004A Accurate data for Clementine 1 has now been received from the Naval Research Laboratory. The spacecraft mass is 230.425 kg dry, 462.392 kg with propellant. The selenocentric orbit for epoch 1994 March 26 is inclination - 89.6°, orbital period - 298.3 minutes, periselene - 435 km, aposelene - 2,904 km.

1994-005A Progress-M 21 undocked from the Mir Complex 1994 March 23.06 and was de-orbited shortly afterwards.

1994-013A Galaxy 1R (#2) has now reached its planned geosynchronous orbit location over 227 °E. Add the following orbital data: 1994 March 4.27, 0.04°, 1,435.94 minutes, 35,725 km, 35,840 km.

Astronauts Memorial

Sir, I was very interested to read the article "The Astronauts Memorial" by H.M. Mason in *Spaceflight*, March 1994. This is the first thorough article describing this memorial I have read. However, there are some facts confusing me a little bit. I miss several names of the deceased astronauts in the list at the end of the article:

Edward G. Givens selected in 1966 died on June 2, 1967 in an automobile accident;
S. David Griggs selected in 1978, flew in STS-51-D, died on June 17, 1989 in an airplane crash; and
Stephen D. Thorne selected in 1985 died on May 24, 1986 in an airplane crash.

On the other hand there is a name of the X-15 pilot Major M.J. Adams who has never been a NASA astronaut. Is this a mistake of the author or is it the real situation coming out from some specifical selection criteria?

LAURENC SVITOK
Bratislava, Slovak Republic

Ed: Howard M. Mason replies: I am aware of the deceased astronauts mentioned in the above letter.

At the time of my visit to the Astronauts Memorial in September 1993, I wrote my article on the sixteen astronauts whose names appear on the Memorial.

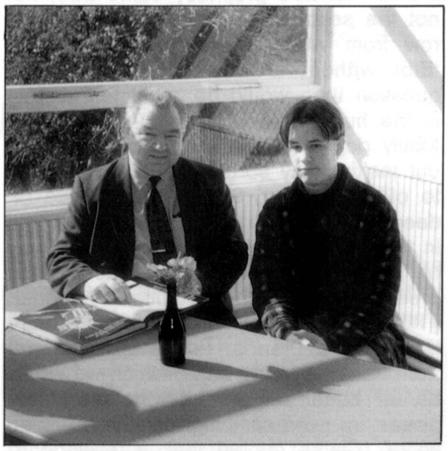
Regarding Major Michael J. Adams' name on the Memorial, according to the definitions laid down by the United States Air Force and United States Navy, flights above 264,000 feet (50 miles) entitled the pilots to wear 'astronauts wings' which Major Adams achieved.

The three North American X-15 research aircraft involved in the joint NASA, US Air Force and US Navy programme made a total of 199 flights between 1959 and 1968.

The research and data made from these aircraft greatly contributed to the development of the space shuttle.

The Editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment on these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

Georgi Grechko Visit



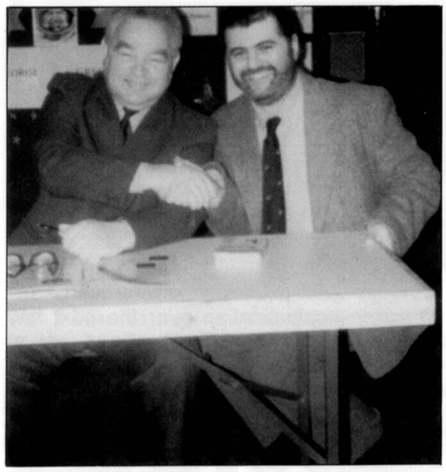
Sir, Cosmonaut Georgi Grechko, a veteran of three space flights, was at the Jodrell Bank Science Centre in Cheshire on 1 April. He spent most of the day touring the facilities before giving a talk in the evening.

I managed to ask Mr Grechko about his three-flight space career, in which he told me that he preferred short-duration missions to longer ones, saying that in the latter case there is a higher danger to the body in terms of the heart, the blood system and the immune system.

He also recalled a humorous incident from his 1977 mission to the Salyut-6 in which his colleague Yuri Romanenko left the safety of the airlock without a tether. Grechko grabbed hold of Romanenko's belt as he floated past, asking him "Yuri, where are you going?"

BEN EVANS
West Midlands, UK

Sir, On 1 April, Tony Bird and I were fortunate to meet cosmonaut Georgi Grechko at Jodrell Bank and to have an interview arranged with him. I enclose a photograph taken on the day of myself with Grechko.



GEORGE A. SPITERI
West Midlands, UK

Apollo 13 Crew

Sir, The caption to the Apollo 13 photograph (*Spaceflight*, February 1994, p.63) requires modification. Lovell and Haise flew on Apollo 13 but Mattingly did not; he was pulled off at the last minute owing to his possible susceptibility to German Measles! The three astronauts had come into contact with the infection but whereas Lovell and Haise were immune poor Ken Mattingly was not. His place was taken by Jack Swigert and Mattingly went to be Command Module pilot on Apollo 16.

DOUG MILLARD
The Science Museum
London, UK

A Young Man's Venture

Sir, When mission STS-60 was launched on 3 February 1994 Sergei Konstantinovich Krikalev became the youngest person to make a third space flight. Born on 27 August 1958 he was 36 years 160 days old at launch. Prior to this the distinction had been held by Pyotr Klimuk who, when launched on Soyuz 30 in 1978, was 35 years 352 days old.

The youngest American is Charlie Walker at 37 years 90 days on STS-61B in 1985, David Low was 37 years 122 days old at the launch on last year's STS-57 shuttle mission.

STUART FARMER
Leicestershire, UK

Mikhail Lisun Visit

Sir, The article in the March 1994 issue of *Spaceflight* regarding the 'Almaz - A Diamond out of Darkness', on page 86-89 is quite an interesting overview of the Almaz programme but would have been better finished off with a photograph of Mikhail Lisun.

I enclose a photograph of Mikhail (second from left) when we were trying on three of his spacesuits that he brought over with him. The others in the photograph are (left to right) Neville Kidger, Mikhail, myself and Eric Hodgkinson.

News items regarding Mikhail's visit in December 1992 appeared in the *Batley News* and *Gnomon*, the newsletter of the Association for Astronomy Education. I will soon be visiting Mikhail again in Star City and no doubt he will be pleased that he has been remembered in Britain.

NICHOLAS E. STEGGALL
West Yorkshire, UK

Adventure and Danger

Sir, I am writing in response to Dr McLaughlin's article, 'Is Adventure Important?', in the January 1994 ***Spaceflight***. I agree with his comment about 'stasis' in human affairs being unsustainable over the long term and the consequent need for action and change.

H.G. Wells wrote (I think it was in 'The Shape of Things to Come') of "not abolishing danger and death, but making danger and death worthwhile". In his day, of course, any exploration of space would have to be human exploration, since no alternative existed.

However, today and in the future from the point of view of the more 'material' aspects of space travel - mining the asteroids, using zero-g manufacturing procedures, extracting complex gases from Jupiter's atmosphere, etc - there is probably little that cannot be done by machines, if less easily than by man. As the article on 'Mission Control in 2023' in the same issue pointed out, computer control systems will probably dramatically increase in sophistication over the next few decades.

Some writers, such as Arthur C. Clarke, have envisaged a future in which the Earth is transformed into one enormous 'park' with mining, production, manufacturing and all other 'messy' bits moved into space, Man having nothing left to do except enjoy all the facilities that our mechanical 'servants' can provide.

Clarke himself was working on the basis that the Earth would be made so safe because it was our 'home', whilst man sought adventure further afield, out amongst the planets and, in time, the stars. Suppose, however, that the first part of Clarke's prophecy came true, but not the second. You might have, to borrow from Wells again, a whole race of 'Eloi' without a 'Morlock' in sight. The question then would be 'what further use is the human race?', since we would be totally dependent on our technology without making any sort of useful contribution to our own lives. Some writers have indeed suggested that computers will come in time to replace us, Man going the way of Tyrannosaurus Rex and various other predecessors on the evolutionary ladder.

It may be that our desire for adventure is no more than an immature remnant from our time in the trees, which we would be far better off without - 'is there any peace in ever climbing up the climbing wave' (Clarke quoted that in 'Prelude to Space', without in any way giving the impression that he thought that we would be better off emulating the 'lotos-eaters').

Some writers, including Clarke again, have suggested that Man's emergence into Space may have long-term effects as profound as those in life's emergence on to dry land. Obviously, for this to be true, there would have to be a much more direct involvement in the space programme than having the whole human race living in computer supplied luxury on the Earth, watching terribly exciting pictures from our various probes and automated outposts.

My above comments have been based on the idea that life in space will continue to be more dangerous than life on Earth. This need not be so. There have been scenarios in which, for example, O'Neill colonies orbit the Earth and provide luxury and safety for their inhabitants, whilst this planet is plagued by increasing nuclear proliferation, pollution, social unrest, etc. One can then imagine a point at which some of these colonies decide to cut their dependence on the Earth, leaving low orbits which may be vulnerable to action from the planet, and heading off to the Asteroid Belt or wherever, balancing the risk of their exodus against the risk of a collapsing terrestrial civilisation taking them down with it. In that way, Man and the various forms of life associated with him might spread across the Galaxy, while his birth-place collapses into chaos and ruin, possibly back to barbarism.

It is likely to be a considerable time before we can determine which of these scenarios is likely to be the correct one. In the meantime, I think we can assume that there will be a role for people in space exploration for the next few years at least, assuming that NASA can get its ideas together.

P.W. DAVEY
Dorset, UK

STS-61 Flight Time

Sir, In ***Spaceflight***, March 1994, p. 81, it is stated that the flight of Endeavour lasted for 10 days 19 hours and 59 minutes. However, the information in *Satellite Digest-262* gives a flight time of 11 days 07 hours and 59 minutes.

KONRAD WERTH
Innsbruck

Ed: See Satellite Digest-265, Additions and Updates, 1993-075A *on p.194 for a revised descent time.*

'Find the Space-Travellers' Competition

With the list of names of those who have journeyed into space now running into many hundreds, this month's competition picks out just nine who share something in common.

Prizes: The first five correct entries to be opened after the closing date of 7 July 1994 will receive a copy of the video*:

STS-61: Mission Highlights

This two-hour video covers the Hubble Repair Mission which took place during December 1993. For more details see inside front cover.

To Enter: Put together each of the following nine 3-letter combinations with two of the following 2-letter combinations in a suitable order to obtain the names of nine cosmonauts/astronauts. Then correctly answer the question below.

AND EAU GAG IYA MAL MAN OLD OUT SHE

AK AR AR BA ER FR GA HM IM IN MA ME MO PA RB RD RN SH

1 .... 6 ....
2 .... 7 ....
3 .... 8 ....
4 .... 9 ....
5 ....

What do these persons have in common ? ....

....

Title/Name ....
Address ....
....
....

Post to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England
To arrive by first delivery on 7 July 1994.
Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

**Tapes are VHS PAL format only and are not compatible with the US NTSC system.*

Animals in Space

Sir, Concerning the article in ***Spaceflight*** (February 1994, p.65), Felix, a French tomcat, was launched from Hammaguir on 1 October 1963 to a height of 140 miles by a Veronique rocket. Electrodes fitted to the cat's head transmitted signals to the experimental base throughout the flight.

Felix is honoured on the above stamp issued by COMOROS (18 November 1991).

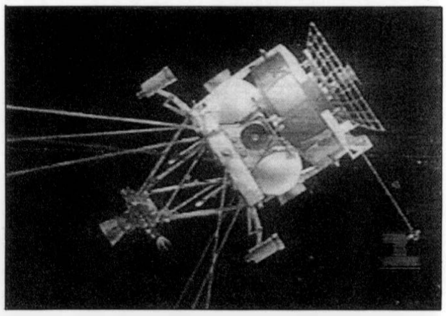
HARVEY DUNCAN
Treasurer Astro Space Stamp Society
Falkirk, UK

Sir, I refer to Henry Matthews's letter (***Spaceflight***, February 1994, p. 65). He is quite right. The French did launch a cat. Felix was taken from the streets of Paris by a cat dealer, having been abandoned, and sent for training in centrifuges and noise boxes having had electrodes implanted in the brain. The intrepid black and white astrocat was eventually selected for displaying the "right stuff" under stress being not too fat or too nervous. Felix was launched on a suborbital flight in November 1963 from the Hammaguir site in Algeria and remains the only feline in space.

On the subject of animals in space and back in 1963, it might interest readers to note that Neil Armstrong faced some stiff competition from a chimpanzee called Howard to be the first living thing on the Moon. After just a year's study at the US Space School, Howard had broken the land speed record on a rocket sledge and had been banned from playing noughts and crosses with visitors because he usually won. The chances are that if a monkey had been sent to the Moon before a man - it would have been Howard.

E.T. PUGH
Essex, UK

Space Defence



Computer image of a Russian space defence satellite weapon from the "Secret Space-Part 1" programme [1].

Sir, A Russian television programme titled *Secret Space - Part 1* has revealed the configuration of the coorbital ASAT, stills of which have been published [1]. These prove that the ASAT is based on the Polyot vehicles which were flown in 1963 and 1964. A photograph of the Polyot published in 1992 [2] shows some minor differences, such as an extra tank and a multi-chamber main propulsion unit, but it is clearly an ASAT without the radar dish and side-mounted warheads. The layout is quite logical for an ASAT, with a generous fuel supply and large side-mounted engines that allow lateral manoeuvres while maintaining a radar lock on the target satellite.

MATTHEW FLAMMER
Virginia, USA

References

1. JPRS-TAC-93-012, 3 June 1993, pp.23-24.
2. *Aviatsiya i Kosmonavtika*, December 1992, p.37.

Develop New Ways

Sir, I wish to reply to the views given by M.M. Hughes (***Spaceflight***, February 1994, p.65) to my letter on the state of NASA.

If you look at NASA's track record over the last seven or eight years you will discover many mistakes and short-sighted policies, some of which are:

- Allowing the cost of space station Freedom/Alpha to grow from $8 billion to $30 billion and thus endanger other programmes. Also the station has yet to be given a purpose and this could lead to cancellation of the project (and not before time).
- Stopping production of the Atlas, Titan and Delta vehicles so that the entire US space programme would be based on one vehicle, the shuttle, that would later go terribly wrong in 1986.
- Grinding the Hubble mirror to the wrong size which took an expensive shuttle mission to put right.
- The loss of the Mars Observer probe due to a 'last minute' modification on its fuel system before it left Earth.
- Allowing the new shuttle Endeavour to be assembled incorrectly.

When faced with such waste and mistakes, is it any wonder that the US Government tightens the purse strings even more?

All this is a sign that the time must be ripe for a new younger US agency that will develop new ways of getting us into space, e.g. by using the near-Earth asteroids as a source of building materials and fuel for a Mars mission.

NASA *really* is leading us nowhere fast.

E. PHILPOTT
South Wirral, UK

The Name 'Buzz'

Sir, I was interested to see Tony Lawton's account of his meeting with Buzz Aldrin (***Spaceflight***, February 1994, p.53), but I would query his statement that the name Buzz derives from his restlessness and ability to work. I have long understood that it came from his younger brother who, unable to pronounce "brother" correctly when he was young, called him his "buzzer".

RAY WARD
Sheffield, UK

Ed: We hear from Gerry Smith, Buzz Aldrin's Business Manager as follows: It was actually Buzz's younger *sister* who had the pronunciation problem and called him her "buzzer".

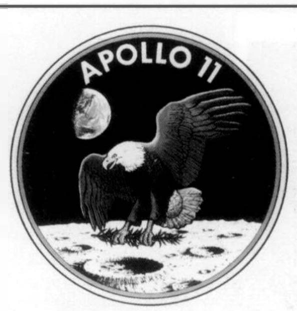
The Tony Lawton version is incorrect. Buzz tended to be energetic, but disciplined, as his ranking at the top of his West Point class and Doctorate from MIT would indicate.

Lives Lost in Space

Sir, With reference to the article on astronaut rescue (***Spaceflight***, February 1994, p.62), I would like to take exception to counting the tragic Apollo 4 fire and its 3 victims as "astronautical fatalities". If they are included, then why not include flight training or transportation accidents, construction of facility accidents, job-related traffic fatalities etc. etc? I would like to recommend the use of very stringent criteria in this case.

HARRY O. RUPPE
Munich, Germany

'Apollo Quotes'
Competition Winners



Lucky readers to whom prizes will shortly be dispatched are:

A. Brocklehurst	Lancs, UK
R. Collett	Staffs, UK
D.F. Hibbins	London, UK
S. van Maele	Belgium
N.E. Steggall	W. Yorks, UK

The correct answers are:

I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth.

Houston, Tranquillity Base here. The Eagle has landed.

That's one small step for man, one giant leap for mankind.

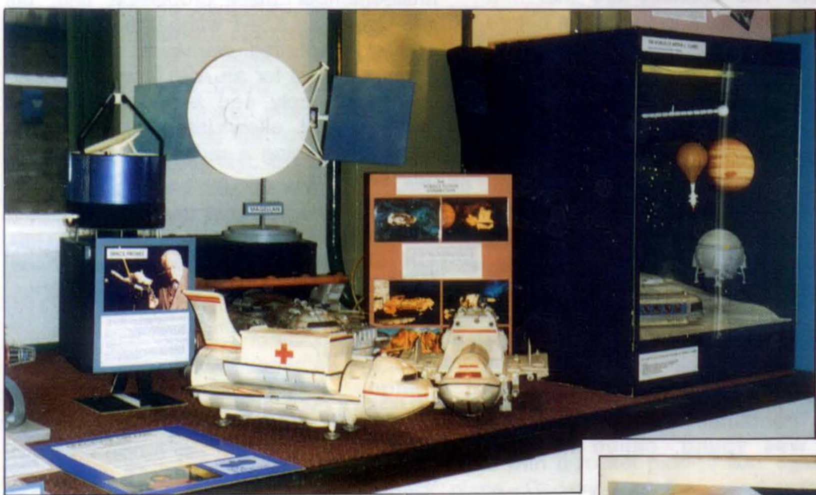
Houston, we've got a problem!

SPACE:

22 March 1994

Left: **A 'Question and Discussion' session in progress with (left) Mark Hempsell, University of Bristol, Tony Lawton, BIS President and Jim Potter, Brunel School for Space Education.**
MAT IRVINE

Right: **Anthony Black helps enquirers at the BIS stand, which highlighted current Society activities and featured its two regular (monthly) publications.**
MAT IRVINE



Left: **A display of spacecraft model design over the years by special effects designer Mat Irvine. The black cabinet features the 'Worlds of Arthur C. Clarke' and models of actual spacecraft are also shown.**

Right: **A display of the work of Ronald Brocklehurst whose interest in the results of astronomical and space research has found expression in these impressive images. A skilled airbrush artist, his current work is done on computer.**

Left: **John Hodges looks on while the 'Orbital Mechanics' Rover activity is operated via computer. The operators' only view of the simulated lunar landscape is through a CCTV, mounted on the Rover. Computer data received from the Rover are used by the operators to decide on courses of action in this sample return scenario.**

From Imagination to Reality with the BIS

Held at Fortress House, New Burlington Place, London

This event was organised by The British Interplanetary Society in conjunction with Channel 4 Equinox, the C4 Science Club, BBC2 Horizon and the Brunel School for Space Education. Its object was to take a look at the past, present and future of space science, engineering and technology from a British perspective. The event was held as part of SET^7; a week of events to raise public awareness and understanding of Science, Engineering and Technology organised by the British Association for the Advancement of Science.

Displays and Exhibits

Displays and Exhibits provided a highly informative addition to the lecture programme and led to much discussion between participants and exhibitors.

List of Exhibitors

British Telecommunications
The BT Education Liaison Unit exhibited samples of resource material for teachers to use with children from age 5 to 18 and covering a wide ability range. Many were relevant to the National Curriculum and included books, videos and computer software.

BBC2 Horizon
During the lunch break, Peter Ceresole introduced a video of the Horizon Programme entitled "Mars Alive".

Mars has vast plains, canyons and huge volcanoes. It could have useful material supplies but would need an increased temperature to provide a working environment for humans. The use of carbon dioxide and other gases and biological organisms could lead to higher temperatures though the process might take 100 years. There are many signs of an earlier presence of water which could now be frozen beneath the land surface. Solar mirrors might also assist the heating process. Terraforming of Mars was presented as feasible in a thought-provoking scenario.

Reaction Engines
Reaction Engines is a British company which, for the past four years, has been working on a spaceplane concept called Skylon, which is referred to in the lecture report overleaf.

Julian Baum
A display of three-dimensional computer graphics and imagery by astronomical and science fictional artist Julian Baum (see page 206).

Photographs on these two pages or the front cover show exhibits by:

British Aerospace Space Systems
Brunel School for Space Education
C4 Science
Mat Irvine
Orbital Mechanics
The British Interplanetary Society
The University of Bristol
Ronald Brocklehurst

The assistance of Richard L.S. Taylor, a recently elected BIS Council member, with SET^7 administrative arrangements is gratefully acknowledged.

SET^7 **In September 1993, at the annual meeting of the British Association for the Advancement of Science, William Waldegrave, Chancellor of the Duchy of Lancaster announced that the BA, with funds provided by the Office of Science and Technology, would be organising a national week of science, engineering and technology in March 1994.**

SET^7 began on 18 March and was the very first nationwide programme of events offering an opportunity for the public at large to see many of the fascinating aspects of science and technology and the career opportunities involved.

The BIS is glad to have been a part of SET^7 in conjunction with Channel 4 Equinox, the C4 Science Club, BBC2 Horizon and the Brunel School for Space Education and to have had this opportunity to promote an awareness in space developments with its programme 'SPACE: From Imagination to Reality with the BIS'.

The display of the Department of Aerospace Engineering, University of Bristol which highlighted space research undertaken by the Department. MAT IRVINE

Opportunities were on hand to find out about the activities of the Channel 4 Science Club.

Jim Potter examines a meteorite on the stand provided by the Brunel School for Space Education, where information on moonrocks and meteorites was available.

SPACE: From Imagination to Reality with the BIS *(continued)*

Tony Lawton, BIS President.

Lecture Programme

The Past, Present and Future in Space Science Technology and Engineering

A.T. Lawton, President BIS
Address of Welcome

Dr Paul Thompson, British Telecommunications, Chairman BIS Programme Committee
Introduction: Benefits of Space Technology - The Contribution to Our Everyday Lives

Alan Bond, Reaction Engines
Getting Into Space - Hotol, Skylon and Spaceplanes of the Future

Dr Robert Parkinson, British Aerospace
Return to the Moon

Peter Ceresole, BBC2 Horizon
"Mars Alive"

Mark Hempsell, University of Bristol
Space Stations and Other Bases

Jim Potter, Brunel School for Space Education
Space and Its Role In Education

A.T. Lawton, BIS President
Closing Commentary: Why the Exploration of Space Is Necessary

Dr Paul Thompson **illustrated many of the benefits now enjoyed from space technology such as world-wide voice, video and data communication available to civil and military authorities, news networks and the public.**

By computer booking, news reports can be switched instantly to different countries. The demand for satellite communications has been doubling every 5 years and Intelsat alone had acquired 64 satellites up to October last. Inmarsat had equipped 26,000 ships for navigation via satellite and the system is also used for search and rescue operations, surveys (e.g. the earthquake damage in Los Angeles) and weather and disaster forecasting. Data from Earth resources satellites now benefit farmers, mineralogists, geologists, oceanographers, surveyors, scientists and environmentalists.

Alan Bond **reminded the audience of the progress made in getting into space since World War 2, of the development of the Atlas Centaur combination, of the launch of communication satellites, Moon surveys, manned missions to the Moon and of probes which had proceeded beyond the Solar System.**

In the 1980s plans were made for a single-stage gas turbine/rocket space vehicle using aircraft principles of horizontal take-off and landing (HOTOL). To save weight, this plane would require a substantial launch trolley which on take-off would be left on the runway. Landing of the returning vehicle would be on its own lighter undercarriage. In the lower denser air the gas turbine principle would be used for propulsion but with increase in height the engine would gradually convert to the rocket principle. This study enabled UK engineers to have beneficial discussions with other countries having similar aims such as France, Japan and the USA.

Despite massive spending on the X-30 NASP in the USA there was no real competition to HOTOL until the Strategic Defence Initiative enabled McDonnell Douglas to propose the Delta Clipper. British Aerospace investigated the development of HOTOL airframe technology in a joint venture with the Russians using the Antonov 225 with a rocket pick-a-back plane. Redesign of the engines and air intakes led to HOTOL's proposed successor, SKYLON, which has increased payload and avoids the need for a launch trolley.

The aim should be to produce spaceplanes to use space ports like modern airports with all their facilities. With economy in the manufacture and operation of spaceplanes will come accessibility to space travel for a wider international, government, commercial and public community. In the future there must be finance, line operators, shareholders, customers, etc similar to the aircraft industry analogy. Three widely-spaced equatorial sites were suggested for space ports, with operating costs reducing with increasing numbers of launches and landings, and perhaps an orbiting space station staging port for Moon journeys.

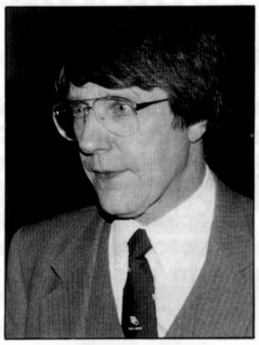
Dr Robert Parkinson **spoke of the need for man to return to the Moon. The first Apollo visitors had to remain within walking distance of the lander in case of equipment failure but with mechanised transport wider exploration is possible, even to the unlit hemisphere.**

There is much data from the Apollo program which demands further local area examination and a search for minerals, gases and useful materials. A small furnace could convert basalt dust into insulation against heat and radiation and, with an epoxy resin, into a concrete product. Using solar power, it is likely that oxygen could be produced from Moon rock. Colonisation of the Moon was considered essential for future human development.

Mark Hempsell **pointed out that since Tsiolkovsky first looked at space flight, space stations have been seen as part of the "classical path" to the exploration of space.**

Although the Apollo programme by-passed space stations to reach the Moon, NASA, along with all other space-faring nations, is now working on an international space station trying to fulfil the vision of the "classical path". However this project is under threat as it has run into serious cost and schedule difficulties due to its ambitious objectives based around prestige and advancing technology.

By concentrating objectives on cost and facilities, and by making stations of appropriate size and technology, much



Alan Bond, Reaction Engines Ltd.

cheaper stations could be built. This would make manned space flight a cheaper and more effective alternative to unmanned spacecraft which is how the original pioneers envisaged the development of space.

Jim Potter **pointed out that there is a shortage of space scientists, engineers and technicians and the government is trying to address the problem in the national curriculum.**

Space embraces all science and it must be taught. Fortunately, space fires the imagination and is therefore useful in teaching subjects. Pupils are unlikely to become astronauts but could become scientists, engineers or technicians. Government must encourage the teaching of space including manned space flight. How else can mining and acquisition of materials from planets and asteroids be achieved?

The audience next took part in a question and discussion session with the afternoon's two speakers.

It was clear that US children have a great expectation about the future space developments because of their education. Children in France and Japan were following similar paths. Britain is a long way behind and Europe generally regards Britain as uninterested in space. It was suggested that interest in space might be stimulated through computer games.

In conclusion, *Tony Lawton* **said that space education is essential to the future prosperity of this country. The government must be made to see this and to take more interest in space matters. The President thanked all participants for attending and for contributing their views and interest.**

ERIC WAINE

Finding Out About...

Rocket Propulsion

Part I - Conventional Systems

Jet Thrust

By way of an introduction to rocket propulsion a few observations are first made about familiar forms of transport.

For most forms of transport the way in which a vehicle is set in motion or kept moving is readily apparent. A motor car is propelled forward by its tyres pushing against the road, a train by its wheels pushing against the rails, a ship by its propeller pushing against the water and likewise a propeller-driven aircraft by its airscrew pushing against the air. In these cases, the ACTION of the tyres on the road, the wheels on the rails, the propeller on the water and the airscrew on the air is met by an equal and opposite REACTION on the particular type of vehicle concerned. As stated by Newton's Third Law of Motion, to every ACTION there corresponds an equal and opposite REACTION. It is this REACTION which sets the vehicle in motion or keeps it moving.

With rocket propulsion, and also with any form of jet propulsion, there is again a REACTION on the object emitting the jet. The object may be a rocket vehicle or an aircraft. This REACTION, or force, is usually referred to as the thrust of the jet. Less readily identified, however, is the force that is the ACTION on account of the absence of any adjacent object against which to push, as with the examples first mentioned.

As might be expected the answer lies with the jet in which a mass of material is moving with a greatly increased velocity. With jet aircraft or rocket vehicles, the material is in the form of gas and its increased velocity means that an increase, and hence a change, in its momentum (= mass x velocity) has taken place.

The elusive ACTION can now be identified as the impressed force required to bring about this change of momentum. As stated by Newton's Second Law, the rate of change of momentum is proportional to the impressed force.

By suitably choosing units for momentum and force, the rate of change of momentum can be equated to the impressed force. This is the ACTION referred to above. Also by Newton's Second Law, ACTION is in the direction of the change of momentum, i.e. in the direction of the jet. The REACTION, or the thrust of the jet, is then in the opposite direction to the jet, which is what would be expected.

Rocket Propulsion

With jet aircraft or rocket vehicles, the high-velocity jet is generated by the combustion of a fuel and an oxidant. For aircraft, the atmosphere provides a readily available oxidant in the form of oxygen that is in adequate supply for generating most required thrust levels.

If however an aircraft needs to take-off from a short runway, an auxiliary rocket propulsion unit can be provided, which carries its own oxidant and is capable of generating a high thrust for a short time. The take-off is then referred to as rocket-assisted. Also, if an aircraft needs to operate at very high altitude where the atmosphere is too thin to provided adequate oxygen for required thrust levels, the aircraft has to carry its own oxidant and a correspondingly suitable power unit: it becomes a rocket plane.

Propulsion that can be effected by a self-contained unit, independent of surrounding conditions, is the characteristic property of 'rocket propulsion'.

For Earth orbiting satellites, space probes or any vehicle that needs to be propelled in the vacuum of space, the only means available is rocket propulsion. In fact, the thrust generated by a rocket is slightly higher when operating in the vacuum of space than under normal atmospheric conditions. The reason for this that, in the presence of a surrounding atmosphere, the atmosphere is unable to exert a pressure on the exit from which the jet is emerging on account of its high (supersonic) velocity. In turn, this causes an imbalance of pressure and leads to a net force on the vehicle in the direction of the jet and hence in the opposite direction to the thrust, thereby reducing the thrust by amounts of up to about 10 %.

Chemical Propellant Rockets

In a chemical rocket, combustion of fuel and oxidant produces gas at an extremely high temperature and pressure (typically 3500 °K and 100 atmospheres respectively), which is then accelerated to a high velocity by expanding it through a nozzle. The shape of the nozzle, which needs careful design to maximise the thrust obtainable, has a profile which initially converges to accelerate the flow to sonic velocity and then changes to a divergent profile to accelerate the flow further at supersonic velocities.

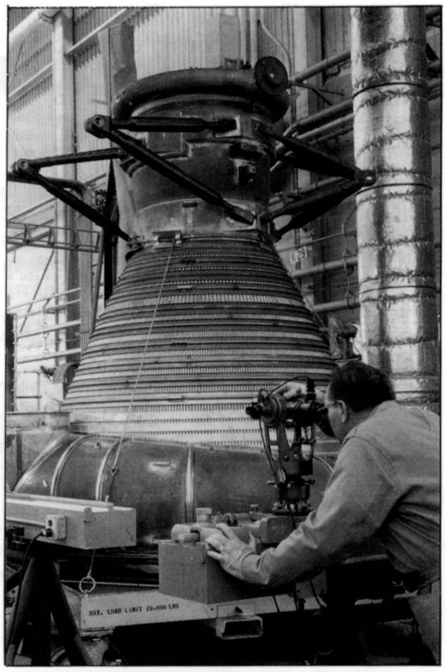
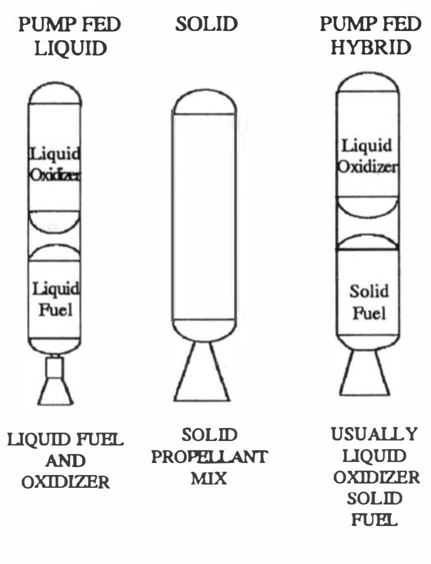


Fig. 1 The F-1 engine used on the Saturn V in the Apollo Program is being inspected in an optical tooling dock to make certain that various attachment points are properly located on the thrust chamber. The length of the engine is 5600 mm, its diameter at the exit is 3640mm and its weight is 8446 kg. NASA

In this way, the initial combustion energy (represented by the high combustion temperature) is converted into kinetic energy of gas flow. The thrust developed, as explained above, is related to the rate at which the jet is generating momentum and hence, since momentum = mass x

Fig. 2 Three principal types of chemical propellant rockets.



velocity, to the rate at which mass in the form of gas is being expelled and the velocity of its expulsion.

The term 'propellant' refers to either the fuel or the oxidant, either of which may be in solid or liquid form. Chemical propellant rockets can use liquid propellants, solid propellants, or a combination of the two and are then called 'hybrids'. Some forms of chemical propellant rockets are shown in Fig. 2.

Most rockets are of the liquid propellant or solid propellant types. Hybrid rockets have been built in small sizes and only recently are experiencing a resurgence of interest because of their inherent safety.

The terms 'rocket motor' and 'rocket engine' are used as follows: a rocket motor contains the propellant delivery system and hence all solid propellant systems are motors; a rocket engine does not contain the propellant delivery system and hence all liquid propellant systems are engines.

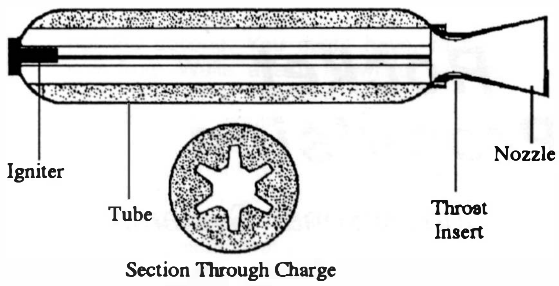


Fig. 3 Solid rocket motor with case-bonded charge.

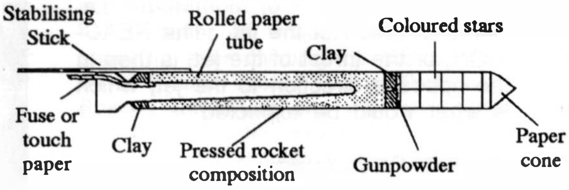


Fig. 4 Firework rocket.

Solid Propellant Rockets

A modern solid propellant rocket, a section drawing of which is shown in Fig. 3, looks remarkably similar to a firework rocket Fig. 4. Versions of firework rockets go far back in history to the ancient Chinese. War rockets were developed by Sir William Congreve and were used by the Royal Artillery until about 1885.

Whereas a firework rocket expends all of its energy in a matter of a second or two, a solid propellant rocket is designed to expend its propellant in a controlled manner over a period of time lasting for some minutes. The fuel and oxidant are both solids, intimately mixed together and formed by a variety of processes into the shape required to give the desired burning characteristics. The propellant casting is called 'the grain' and generally has the appearance and texture of hard rubber. It is contained within and bonded to a high strength metal or fibre composite casing that must withstand the high combustion pressures. Burning takes place on the surface of the grain, the geometry of which is designed to have a controlled burning area throughout the burn process to meet the required thrust *v.* time performance. Some typical solid propellant mixtures are listed in Table 1.

The combustion chamber exit converges to the nozzle throat, which acts as a choke on the combustion products, enabling operation at a chamber pressure that is most efficient for the particular design. The combustion products then accelerate through an expansion nozzle before leaving the rocket.

Special materials are used for the throat and nozzle to withstand the high exhaust temperatures (2000-4000 °K). Carbon phenolic and graphite are common materials used in the throat. Graphite composites and ceramics are examples of materials that may be used in the expansion nozzle.

Solid propellant rockets have the advantage of being ready to launch on demand because they stand fully loaded. A principal disadvantage is that, once started, solid propellant motors cannot be shut down on the launch pad unless the motor is vented in some way.

Examples of solid propellant rockets are the boost rockets for the Space Shuttle and Titan launchers.

Liquid Propellant Rockets

Types of liquid propellant rockets that have been developed are shown in Fig. 5 for pressure-fed and pump-fed propulsion systems,

Rocket launch vehicles can use either turbine driven pumps or high pressure tanks to feed propellants into the rocket engines. The preferred design for large bi-propellant rockets is to use turbine driven pumps. This enables engineers to design for higher efficiency light-weight propellant tanks, which has a major effect on the efficiency of the launch vehicle. Large pressure-fed rockets, although simple in concept, have not been successfully developed, due to the high weight of the propellant tanks. Whereas the tank wall thickness on a pressure fed rocket may be a millimetre or more, the tank wall thickness on a launch rocket like the Atlas or Centaur is only a few forthieths of a millimetre (thousands of an inch), resulting in an order of magnitude less weight.

Pressure-fed liquid rocket systems are useful in small sizes as control devices on launch vehicles and spacecraft. The Orbit Manoeuvre System (OMS) on the Space Shuttle is a pressure fed bi-propellant rocket system. It is used to accelerate the Shuttle into Earth orbit after the external tank is dropped, to manoeuvre the Shuttle to new orbits and to apply retro-thrust to allow the Shuttle to re-enter the atmosphere to land.

With monopropellant rockets, hot gas is generated by decomposition of a single propellant in a rocket chamber. Their efficiency is less than bi-propellant rockets as the gaseous products have a lower energy content. A once common monopropellant, hydrogen peroxide, is decomposed thermally or catalytically by passing it over a silver-gauze catalyst, the products of decomposition being steam and oxygen. Hydrazine is also another monopropellant, which is more commonly used today. Its products of decomposition are hydrogen, ammonia and nitrogen gas. Hydrazine is the currently preferred propellant for the small control rockets used on spacecraft. Like pressure-fed bi-propellants, monopropellants are used only in small rockets, some providing only a few grams weight of thrust.

Liquid propellants are generally classified as "storables" or "cryogenics". Storable propellants are those that are liquid at ambient temperatures and pressures. Kerosene is a typical storable fuel. Cryogenic propellants are those that are in a liquid state at very low temperatures. Liquid oxygen, with a boiling point of 89 °K, is an example of a cryogenic propellant. Liquid hydrogen, the most energetic of readily available fuels, has a boiling point of 20 °K. This propellant is so volatile that special care is required to insulate propellant tanks and lines

Table 1: Some typical solid propellant mixtures.

Double-base Propellent (fuel and oxidant chemically mixed)	%	Composite Propellent (fuel and oxidant mechanically mixed)	%
Nitrocellulose	51.4	Ammonium perchlorate (NH_4ClO_4)	62.0
Nitroglycerine	42.9	Binding material (fuel also)	21.9
Additives	5.7	Aluminium powder	15.0
		Additives	1.1
Total	100.0		100.0

against the much higher ambient temperature. An un-insulated container would rapidly condense rivers of liquid air on its surface, causing the hydrogen to rapidly boil away.

Some propellants are highly toxic and require special handling. Nitrogen tetroxide and fluorine are examples of highly toxic oxidisers. Hydrazine is an example of a toxic fuel. Table 2 lists some commonly used propellants. An exception is liquid fluorine, which has not yet been used in a production rocket.

Rocket Engines

Rocket engines driven by turbopumps are extremely high power devices (generating many thousands or even millions of horsepower) and consume large quantities of propellant for their physical size. A typical engine will be equipped with a centrifugal pump for each propellant. The pumps may be driven by a single gas turbine, or each pump may have its own turbine. The power source for the turbine is usually a gas generator, which itself is a small rocket motor whose exhaust products are at a low enough temperature for operating the turbines. Depending on the design of the engine system, the gas for operating the turbine may be a fluid that has become gasified on acting as a coolant to the main chamber.

There are several designs, or "combustion cycles" for rocket engines, which have evolved from perceived needs to maximize engine efficiency. The simplest and earliest cycle, and also the least costly, uses a gas generator for powering the turbines. It is, however, the least efficient. Alternatively, propellants for operating the gas generator may be taken from the high pressure feed lines between the pumps and the main combustion chamber. Exhaust from the turbines may be piped overboard, or may be ducted into the main exhaust nozzle. Sometimes a heat exchanger is installed in the exhaust line to vaporize gas for pressurization of the main propellant tanks. This feature is called "autogenous pressurization", and eliminates the need to carry separate pressure bottles for tank pressurization.

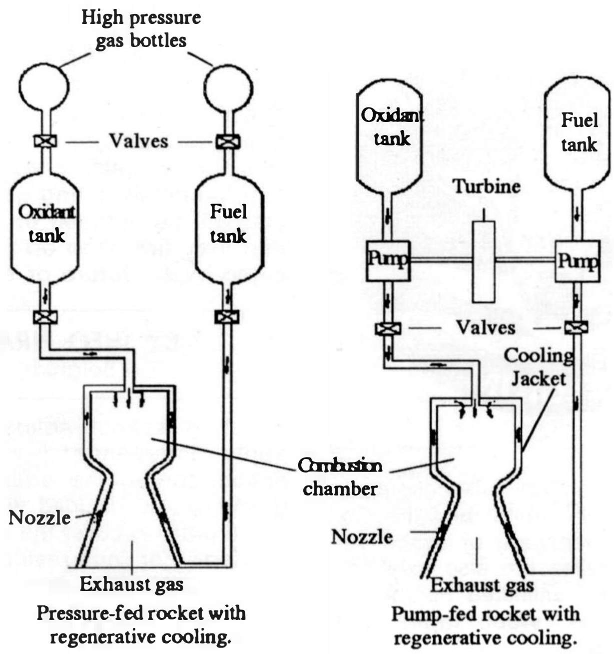


Fig. 5 Simplified schematics of pressure-fed and pump-fed propulsion systems.

Propellants are pumped into the combustion chamber through an injector plate at its forward end. The oxidiser usually enters the injector directly but the fuel takes a circuitous route through tubes that are a part of the chamber wall and nozzle before entering the injector. The wall of the chamber is thus cooled so that burn-through does not occur. The process is called "regenerative cooling". The injector plate is made up of numerous holes, positioned so that an individual oxidiser jet will impinge on a fuel jet. This promotes the good mixing required for efficient combustion. An engine such as the F-1, the boost engine used on the Saturn in the Apollo Program, has a total propellant flow rate of 2,600 kilograms per second, so good mixing is imperative.

If *thrust vector control* is required, a common method is for the thrust chamber to be attached to the launch vehicle *via* a gimbal block at its forward end. This allows the engine to swivel, to provide steering for the rocket. There are also two lugs attached to the wall of the chamber, to which hydraulic actuators are attached. These actuators provide the force for gimballing the engine in any direction, usually by not more than five degrees. Fig. 1 is an illustration of the F-1 engine of which 65 were used in 13 Saturn flights.

Propulsion Performance

The most useful parameter for determining rocket motor (or engine) performance is *specific impulse*, which is defined as the impulse delivered per unit mass of propellant. In SI units, impulse (= thrust x time) is measured in Newton-seconds (Ns) and specific impulse in Ns/kg. The range of values used in performance calculations is:

Specific impulse
(sea level) 1275 - 3825 Ns/kg
(in vacuo) 2110 - 4610 Ns/kg

An 'effective' exhaust velocity of the jet is sometimes introduced. From its definition as the thrust per unit rate of mass flow of propellant, it follows that it is numerically the same as the specific impulse as defined above with SI units of m/s.

Specific impulses are sometimes quoted in units of seconds, corresponding to a modification of the above definition to that of the impulse delivered per unit *weight* of propellant. Such values in seconds then follow from those in Ns/kg on dividing by g (= 9.8 m/s^2), the acceleration due to gravity at the Earth's surface. ■

This article has been compiled by L.J. Carter, BIS Special Projects Officer with the assistance of Fellows of the BIS from material prepared for publication as an Education booklet.

Table 2: Some typical liquid propellants for rockets.

	Chemical Formula	Density kg/litre	Boiling Point °K	Appearance
Oxidants				
Liquid oxygen	O_2	1.14	89	pale plue
Nitric Acid	HNO_3	1.51	358	colourless or red
Hydrogen peroxide	H_2O_2	1.45	423	colourless
Liquid fluorine	F_2	1.51	84	pale yellow
Nitrogen tetroxide	N_2O_4	1.45	294	reddish brown
Fuels				
Hydrocarbon fuel	CnH_2N	0.81	450-540	colourless
Hydrazine	N_2H_4	1.01	386	colourless
Ethyl Alcohol	C_2H_5OH	0.79	351	colourless
Liquid Hydrogen	H_2	0.07	20	colourless

Euro Space Center

The Euro Space Center, operated by the Belgium company CISET International, is a unique educational leisure centre in Europe. Its purpose is to reveal the fascinating world of astronautics. Its brochure invites you to 'enter a different world and get a feeling of what is out *there*'. Throughout the visit, you will be updated on everything that has happened since Armstrong took that very first step on the Moon. You will also catch a glimpse of what is to come in the future of space exploration such as a journey to Mars.

BY THEO PIRARD
Belgium

Exhibition

In the exhibition are full-scale models of the Shuttle Orbiter and the Columbus APM. Hardware of space vehicles and satellites are also exhibited together with an unlimited number of satellite pictures, video tapes and many mock-ups.

Four audio-visual shows (Auditorium, Holorama, Planetarium and Show Scan) provide entertainment that will transport the visitor through space to come within touching distance of stars and once unattainable planets, to travel faster than light, visit extraordinary planets and see the Earth from a very different angle.

In addition to the actual exhibition, visitors are likely to see the young trainees of Space Camp (maybe our future astronauts) in training and working on simulators. This all creates the atmosphere of a real astronaut training centre.

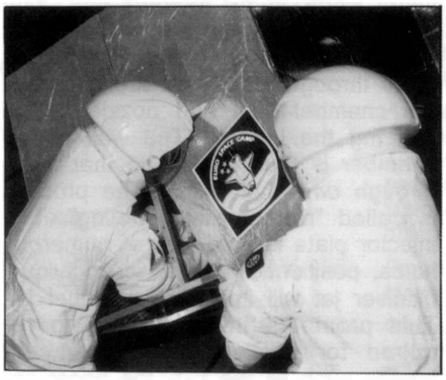
Space Camp

Space Camp is for young people from 10 to 18 years of age and is unique in Europe. There are various camp formulas that vary from half a day to a full week during holidays or with a school class during school term.

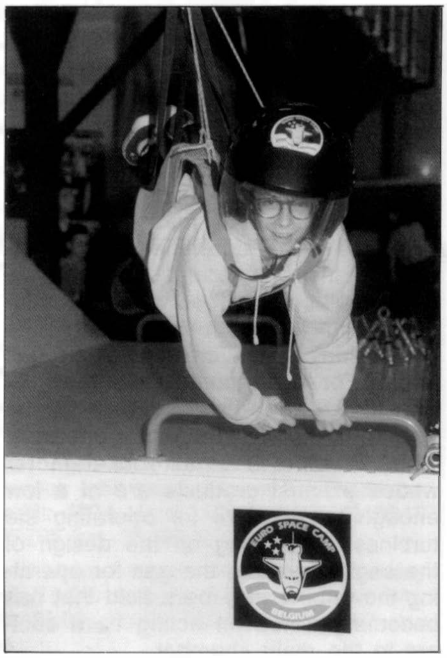
During school holidays, children apply independently but, during school terms, the educational programmes are decided with the teachers in order to cover the subjects being studied. For non-residents, training courses last either half-a-day or a full day. For longer stays of 2 days (at a week-end) or of 3 or 5 days, board and meals are then included.

There are three different levels of activities based upon the age of participants:

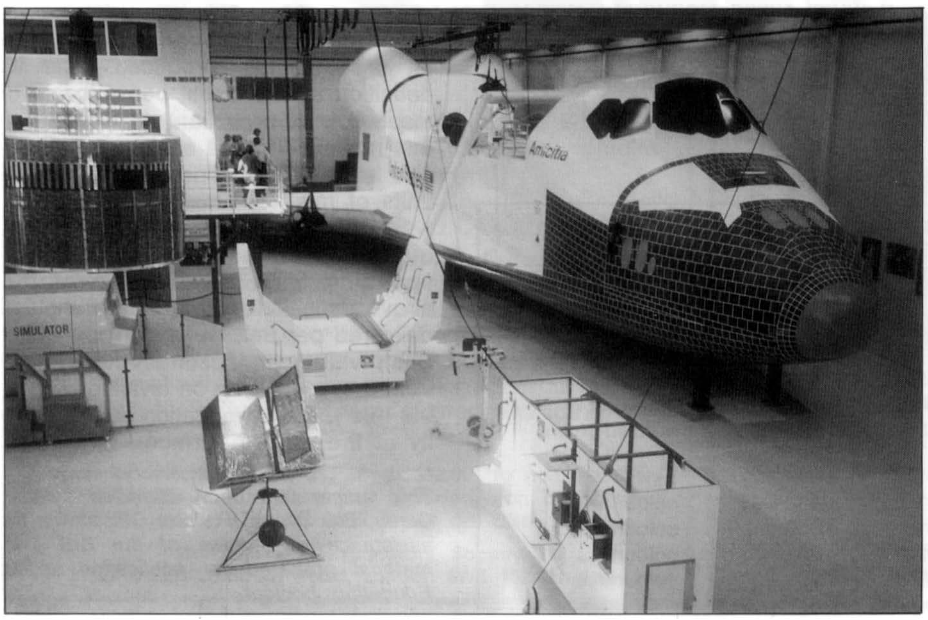
Space Camp (10 - 12),
Space Academy 1 (13 - 15) and
Space Academy 2 (16 - 18).



Above and right: **"Euronauts" during a training session.**



This full-scale mock-up of the Space Shuttle Orbiter is named Amicitia and is used for the training of the "Euronauts". It is unique in Europe!



The activities are adapted to the capabilities and interests of each age group.

However, for slightly older astronauts, camps for adults and seniors are arranged by request.

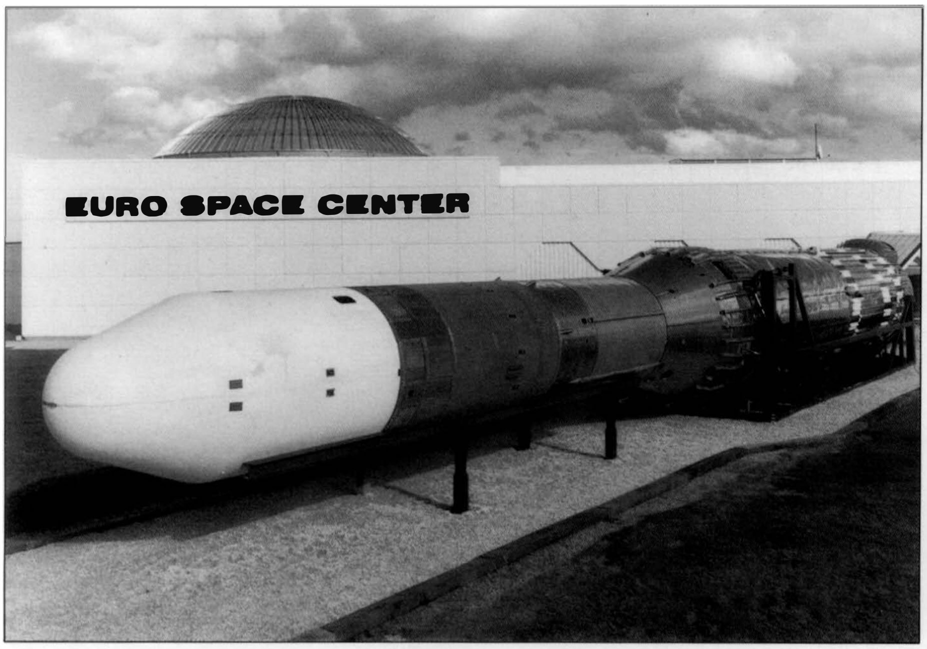
Space Camp for non-residents includes a visit of the centre, a demonstration of astronaut training equipment and construction of a micro-rocket.

Space Camp for residents offers classes, flight simulation missions and physical training on simulation equipment. Participants can float with the microgravity simulator, be turned upside down in the multi-axis chair and get very wet, working on underwater structures.

A visit to the Euro Space Center can be combined with other visits in the area to such places as the national telephone company Belgacom-Lessive, Redu the Book Village or with a canoe circuit.

Each year, the Euro Space Center organises a Space Summer on a specific space theme. From May to September 1994 it celebrates the 25th anniversary of the first manned landing on the Moon. The exhibits which include a space suit, Moon rocks and some souvenirs of the 1960s will be opened by Alan B. Shepard.

During 1993, the Euro Space Center welcomed some 72,000 paying visitors.



The Europa rocket on display in the forecourt of the Euro Space Center.

Space Summer 1993 began on 7 July 1993 with the transfer of the "Europa" rocket from the village of Redu to the Euro Space Center.

The Europa rocket represents the first attempt of Europe to develop an independent access to space. This liquid three-stage vehicle, 30 m high and 3 m in diameter, consisted of a British Blue Streak missile as first stage, the French Coralie rocket as second stage and a German Astris upper stage. Europa was designed to achieve the performance of 1 ton into a 500-km circular orbit.

From November 1968 to June 1970 - while NASA was triumphant with the Apollo Program - three test flights with an Italian technological payload were made from Woomera (Australia) without success. On 5 November 1971, a fourth attempt, with an upgraded version, named Europa 2, was made from Kourou (French Guiana) where a new launch facility had been built: because of electrical incompatibility between the systems aboard Europa, this flight ended in a dramatic failure.

The Ministers of the States who were members of ELDO (European Launcher Development Organisation) decided in the Spring of 1973 to stop the Europa Programme. After an investment of some $745 million, there were Europa vehicles which had no further use. One of these, which was planned to launch the French-German Symphonie 2 communications satellite, was transported in 1974 to a place closeby the village of Redu (in the Belgian Ardenne) for a public space technology exhibit and then remained located there. Its presence largely contributed to the birth of the Euro Space Center.

The burgeoning European space industry has learnt a lot of technical management lessons from the ill-fated Europa Programme. This was a dramatic experience which has contributed much to the success of the Ariane launch programme.

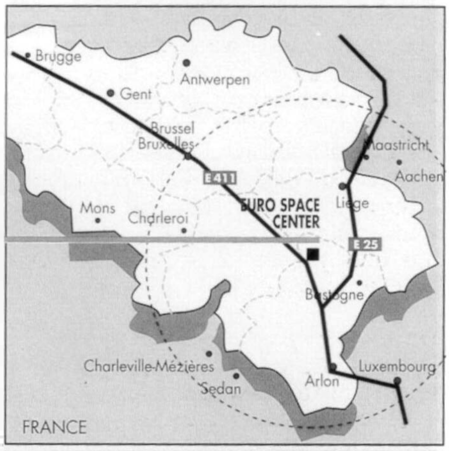
In the Heart of Europe

In the Belgian Ardennes, the Euro Space Center is located on a beautiful site, surrounded by green countryside. Easily accessible with the Highway E411 (exit 24), it is situated midway between two major European cities Brussels and Luxembourg and right in the heart of Europe.

Opening Hours

The Euro Space Center is open everyday from 10:00 am to 5:00 pm.

(All photographs supplied by the author)



Symposium

Space Industrialisation as a Response to Global Threats

to be held on Thursday, 23 June 1994, 10 am - 4.30 pm at

The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ

The symposium aims to cover all uses of space which respond to global threats to man on the planet, such as:

- monitoring of the Earth from space
- protection from comets and asteroids
- missile defense systems
- space energy
- space industry off-load
- space resources

Advanced Registration is necessary. Limited student concessions available on request. Registration forms are available for the Executive Secretary. Tel: 071-735-3160.

Provisional Programme

Dr A.R. Martin, AEA Technology
Space Industrialisation as a Response to Global Threats - An Overview

A. Bond, Reaction Engines Ltd
The Exploitation of the Moon to Substitute Terrestrial Resources

D. Ashford, Bristol Spaceplanes Ltd
Sub-Orbital Tourism - The Key to Space Industrialisation

M.C. Bernasconi, The OURS Foundation, Switzerland
The Space Option and Our Future: Some Considerations on the Thermal Burden

C.M. Hempsell, University of Bristol
An Historical Review of Space and Limits to Growth

Dr A. Hansson
Space Industrialisation and Peace of Mind

Shoemaker-Levy 9 - first impact.

Encounter with Jupiter of Comet Shoemaker-Levy 9 (SL9)

SL9 in Virtual Space

Telescopes big and small, back garden, mountaintop and orbit, probes old and new, are all awaiting the big event on the face of Jupiter we cannot see.

As well as the few pixels of data that the long vigils will be trying to catch of the elusive brightenings, what, we might ask, would an observer see flying along the string of pearls, or hovering above the boiling clouds as tiny fragments blast silent fireballs thousands of miles high?

Not too long ago, the answer would have been provided by a project rooted in the domain of paint and brush, or models and camera. Though the artist still begins with a blank page, a very elegant combination of all traditional effects is possible with the advent of image processing and photographic quality 3D computer graphics.

My work on depicting the SL9 impact event began with a basic overview of the space around Jupiter: we know what Jupiter looks like, where it is in July and where the fragments are likely to hit. From these simple facts, a few compositional sketches were produced, a simple three dimensional oblate spheroid providing the shape onto which a painting of Jupiter's cloud belts could be wrapped. A handful of boulder shaped objects, formed from freehand cross sections, aligned and then joined by a meshed skin, were positioned one after another on their 'descent' to Jupiter.

As in the real world, so in the arcane void of virtual space, you have cameras and lights to view and illuminate your models. A global light source, behaving like the Sun and simulating parallel rays, was swung round to backlight the spheroid of Jupiter. This was the setup for most of the long shots and was of course the most dramatic and necessary as the fragments will impact on the nightside.

Next the camera was moved close to the string of pearls to achieve a steep perspective and the notion of a long sweep of glowing comets culminating in a bright nuclear blast. Finally, this formed the basis for three of the images, one of which is shown on the opposite page.

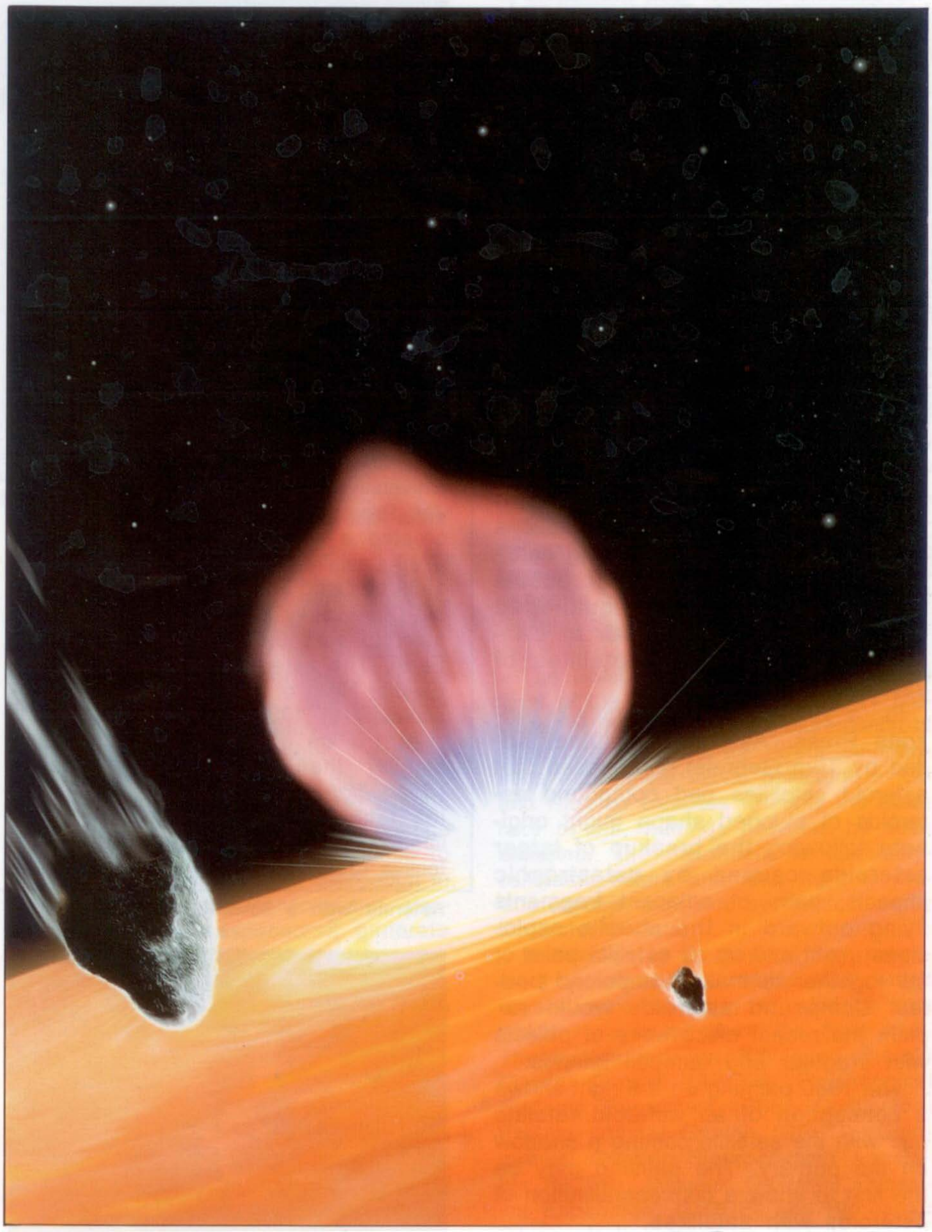
The intention is always to simulate an event, real or imaginary as realistically as possible. With 3D graphics, you must pay close attention to every detail at every stage. The ridges and craters of the fragments are achieved by the process of bump mapping. Each fragment is built and rendered separately, retouched and composited with the rest to form a diminishing line. Jupiter is pasted behind the line, then carefully slid into position. Explosions are painted and filtered, then pasted with soft edges to blend seamlessly with the final picture.

With the image of the erupting fireball (shown below), the shape itself was drawn as a 2D half cross section, then rotated or lathed around an axis to produce the 3D fireball. The addition of a blast pattern at the base, and the expanding shock waves on the surface were all hand painted.

We can only guess how the real impacts will look and perhaps no imagined image can do justice to what will be an awesome and terrifying dawn on Jupiter. In anticipation and remembrance of a great and rare event, I have been pleased to donate a set of these prints to the British Interplanetary Society.

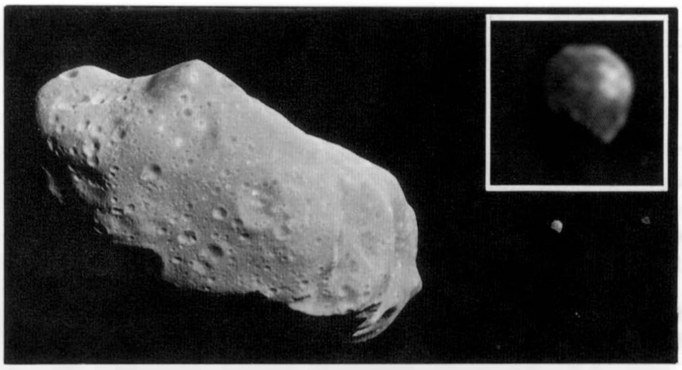
JULIAN BAUM

Shoemaker-Levy 9 - comets, impacts and fireballs.



J. Baum, Feb. 1994

Ida Moon Discovered



The first full picture showing both asteroid 243 Ida and its newly discovered moon to be transmitted to Earth from NASA's Galileo spacecraft. The inset is a closeup of the moon, being a magnified, processed version of the only view of it so far transmitted by Galileo to Earth. Ida is about 56 km long and its moon is about 1.5 km across as seen here. JPL

NASA's Galileo spacecraft has taken the first ever photograph of a moon of an asteroid. Although Galileo took pictures of the small moon of the asteroid 243 Ida during its flyby on 28 August 1993, the images were not received on Earth until recently because the spacecraft is transmitting over its low-gain antenna at a very slow rate.

Ida is about 56 km long. The photograph was taken by Galileo's charge-coupled device (CCD) camera on August 28, 1993, about 14 minutes before the spacecraft's closest approach to the asteroid, from a range of 10,870 km. Ida is a heavily cratered, irregularly shaped asteroid in the main asteroid belt between Mars and Jupiter and is the 243rd asteroid to have been discovered since the first one was found at the beginning of the 19th century. It is a member of a group of asteroids called the Koronis family.

The small satellite, which is about 1.5 km across in this view, has yet to be given a name by astronomers. It has been provisionally designated "1993 (243) 1" by the International Astronomical Union. (The numbers denote the year the picture was taken, the asteroid number and the fact that it is the first moon of Ida to be found). Although the satellite appears to be "next" to Ida it is actually slightly in the foreground, closer to the spacecraft than Ida. Combining this image with data from Galileo's near-infrared mapping spectrometer, the science team estimates that the object is about 100 km away from the centre of Ida. This image is one of a six-frame series taken through different colour filters. The spatial resolution in this image is about 100 metres per pixel.

The overall shape, size, rotation and orbital motion of the natural satellite are still unknown. The Sun's illumination is falling on it from the upper right. The black "gouge" in the body's shape toward the lower left is probably more apparent than real, and is mostly a part of the shadowed night side of the little moon. A rugged landscape, including one or two craters, appears to be present, although the smallest features that can be detected in this picture are about 1/7th the diameter of the natural satellite.

It is hoped to soon receive other views of Ida's moon which are currently stored on Galileo's onboard tape recorder; one of those images is expected to be at least three times sharper than this one.

Astronomical Art

Binary Asteroid Picture

The discovery by the Galileo spacecraft of the first confirmed satellite companion of an asteroid, follows early unconfirmed indications from occultations and from double impact craters on the Erath and other worlds that some asteroids might have satellites.

In the late 70s there were unconfirmed reports of double occultations of stars by asteroids - implying satellites. Also, various pairs of double craters, including the equal-aged Clearwater Lakes crater pair in Canada, suggested some satellites of asteroids.

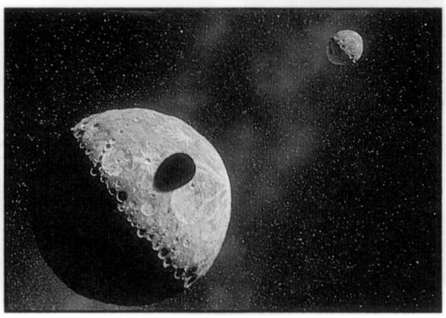
In a 1979 paper (University of Arizona Press "Asteroids" volume, edited by Tom Gehrels), I proposed that asteroid satellites and compound asteroids of bi-lobed shape might originate following the breakup of larger asteroids caused by catastrophic impacts; pairs of adjacent fragments flying outward in the chaotic explosions might end up as satellite pairs or fall together to make compolund bodies. Compound asteroids would explain the recent discoveries of objects with irregular and dumbell shapes.

The 1980 painting on the right shows a conception of an asteroid-satellite pair with the satellite casting a shadow on the primary. The painting may be the first to show a conceptualisation of asteroids with satellites.

WILLIAM K. HARTMANN

Asteroid with a satellite.

© Wm. K. HARTMANN 1980

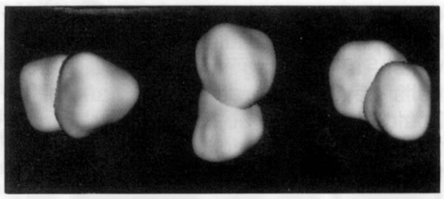


Radar's 3-D Image

Two NASA-sponsored scientists have produced the first-ever detailed, three-dimensional reconstruction of one of the thousands of asteroids in the Solar System whose orbits bring them extremely near to Earth.

Scott Hudson of Washington State University and Steven Ostro of NASA's Jet Propulsion Laboratory (JPL) have created a computer model of asteroid 4769 Castalia from radar data obtained in 1989 by Ostro and others, using the Arecibo Observatory in Puerto Rico, when the asteroid was 5.6 million km from the Earth. The asteroid was discovered by Eleanor Helin of JPL at the Palomar Observatory in 1989.

At 1.8 km across, Castalia is much smaller than the asteroids Gaspra (*Spaceflight*, February 1992, p.57) and Ida (shown above) which have been imaged by the Galileo spacecraft. The effective resolution in this reconstruction is about 100 meters. Previously it has been difficult to interpret radar images of small, irregularly-shaped bodies. But with the development of a new reconstruction technique, the scientific value of radar observations has been dramatically enhanced.



Three different views of a computer model of the near-Earth asteroid 4769 Castalia. This is the first detailed 3-D model of a near-Earth asteroid yet produced, and the most conclusive evidence to date of a "contact-binary" object in the Solar System. JPL

The double-lobed shape of Castalia shown by the model is believed to have resulted from a gentle collision between two separate asteroids some time in the past. Nearly 300 near-Earth asteroids are currently known. It is thought that more than 1,000 as large as Castalia, plus 100 million as large as a house, remain to be discovered. Most of them are thought to have been thrown into the inner Solar System from the main asteroid belt, between Mars and Jupiter, by long periods of gravitational interaction with the planets. With unstable orbits, they eventually might be thrown out of the Solar System by the same forces or possibly collide with planets.

The Castalia model confirms the suspicion that near-Earth asteroids may be the most irregularly shaped bodies in the Solar System.

Giant Galaxy NGC 1399

Rotation Implies 'Lots of Dark Matter'

Giant Galaxies

Galaxies are the basic building blocks of the Universe. Some look like spinning spirals, like our own Milky Way galaxy, with its several hundreds of billions of stars in a flat, rotating disk. Some galaxies lead a comparatively quiet life, others are violent and explosive. But perhaps the most enigmatic of them all are the largest ones, the *giant elliptical galaxies.* They are huge collections of stars and hot gas, 100 times brighter than the Milky Way and in many of them, the hot gas is a powerful emitter of radio waves and X-rays. The giant galaxies are mostly found at the centres of vast clusters of hundreds or thousands of smaller galaxies, like swarms of bees about the central hive.

How did these great galaxies form at the centres of their clusters? Astronomers who make computer simulations of the early Universe believe they know the answer. In their simulations, they see these giant galaxies forming by gradual aggregation of small clumps of matter falling towards the centre, thereby making larger and larger bodies as time progresses. But how sure can we be that this theory is correct? It turns out that a crucial test is to measure how the matter now moves in the outskirts of these huge galaxies, at distances of 100,000 light-years or more from their centres.

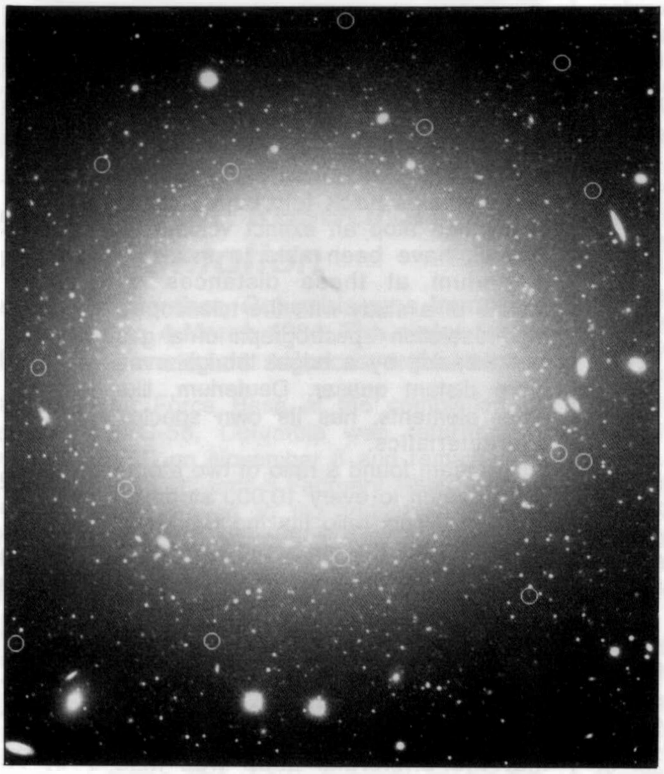
Motions in Giant Galaxies

Rotation in galaxies comes originally from clumps of matter raising tides on each other through their gravitational pull, just as the Moon raises tides on the Earth. The tug of these tides makes the clumps spin. When the swirling clumps come together in computer simulations of what is going on in a newborn galaxy, they keep interacting, and the amount of swirling motion ("angular momentum") gradually shifts outward into the far outer regions of the new galaxy.

If this theory is correct, we should therefore now see slow rotation in the inner parts of the giant galaxies, but quite rapid motion in their far outer regions. The first part is not too difficult to check observationally: the inner parts of giant galaxies are relatively bright and we can easily measure their rotation from the observed Doppler shift of the light from the stars and nebulae which are located there. However, to measure the rotation in the outer parts has, until now, proved impossible, because the light there is just too faint to be observed, even with large astronomical telescopes.

Planetary Nebulae as Beacons

Fortunately, a few years ago it was realised that there are some excellent beacons that we can use to measure the swirling motion far out in giant galaxies. These are the planetary nebulae that are created during the last dying act of stars like the Sun. Such objects are rare, because the planetary nebula phase does not last long in astronomical terms, but in these huge galaxies a few hundred of them may still be present in the outer regions at any time.



Some of the very faint planetary nebulae (circled) in the giant elliptical galaxy NGC 1399. The central part of the galaxy is "overexposed" in order to bring out the point-like images of the planetary nebulae. CTIO/ESO

The luminous gas in a planetary nebula emits most of its light at one particular wavelength in the green part of the spectrum, being emitted at 500.7 nm wavelength by doubly ionised oxygen atoms. This fortunate concentration of the light energy makes it possible to see them and to measure the velocities of individual planetary nebulae in galaxies, even at relatively large distances.

The present international team of astronomers who are involved in this field of work had earlier used planetary nebulae to study the motions in several nearby galaxies (closer than 20 million light-years), but never before had they attempted to investigate a giant elliptical galaxy. This is because even the nearest of these rare objects is so far away (50 million light-years) that the light from its planetary nebulae is extremely faint and therefore in principle out of range for existing astronomical telescopes.

Attempting Observations of NGC 1399

Nevertheless, the team decided to try using one of the best optical telescopes in the world, the ESO 3.5-metre New Technology Telescope (NTT) at La Silla in Chile. They applied for observing time and were pleased to obtain three nights in November 1993.

The object of their investigation was the giant elliptical galaxy NGC 1399, the supposedly nearest galaxy of its type and located at the very centre of one of the largest clusters of galaxies in the southern sky, the Fornax cluster (referring to the constellation towards which it is seen). The visual magnitudes of the planetary nebulae in NGC 1399 are around 27, i.e., they are 250,000,000 times fainter that what can be seen with the unaided eye. It is not too difficult to record direct point-like images of each of them with the NTT. However, the measurement of their motions implies that this sparse light must be dispersed and spectrally analysed, an almost impossible feat for such faint objects.

For this daunting task, the astronomers used the ESO Multi-Mode Instrument (EMMI), which incorporates a multi-object spectrograph that allows measurement of the velocities of several planetary nebulae at once.

Before the observations can begin, the exact positions of the planetary nebulae are measured. A metal mask is then prepared with holes that permit the light from these objects to pass into the EMMI, but at the same time blocks most of the much brighter, disturbing light emitted by the Earth's atmosphere. With an additional optical filter, all but the green light is effectively filtered out.

Velocities of Planetary Nebulae in NGC 1399

The careful preparations paid off and during two of the allocated nights (the third was lost due to bad weather), the Australian observers (Magda Arnaboldi and Ken Freeman) were able for the first time to measure individual velocities for 37 planetary nebulae in NGC 1399. The difficulty of this observation is illustrated by the fact that in order to catch enough light from these faint objects, the total exposure

time was no less than 5 hours and only one field on either side of the galaxy could be observed per night.

While at the telescope the astronomers realised that the new results were very exciting; this was fully confirmed by the following long and complicated process of data reduction. In fact, although the inner parts of this galaxy rotate quite slowly, the planetary nebulae in the outer regions are in rapid motion and clearly indicate a fast rotation of these parts of the galaxy.

This new observation is just as expected from the above described theory for the formation of giant galaxies and therefore provides very strong support for this theory.

Lots of Dark Matter in NGC 1399

Perhaps the most exciting result is that these measurements also allow an estimate of how much of this giant galaxy is in the form of dark matter. From the large spread in the observed velocities of the 37 planetary nebulae, it is apparent that the total mass of NGC 1399 must be very large, and that no more than ~ 10% of this mass is contained in the stars and gas that we observe in it, i.e. the remaining 90% of the mass of NGC 1399 must consist of dark, "invisible" matter.

This is another very clear observational confirmation of the apparent presence of dark matter in the Universe, already indicated by various other astronomical investigations. Although many suggestions have been made about the nature of this dark matter, nothing is known for sure at this moment.

The most important implication of the existence of dark matter is that its gravitational attraction may be sufficient to ultimately stop the current expansion of the Universe. If so, it will later begin to contract, probably leading to a "Big Crunch", many billions of years from now.

Dark Matter may be Exotic Stuff

The observed abundance of deuterium in the distant (younger) universe implies that virtually all ordinary matter that exists has been detected.

In Big Bang theory, specific fractions of the lighter elements were produced immediately after the primordial explosion 10 to 20 billion years ago. The observed ratio of deuterium to ordinary hydrogen is considered a fossil clue to the density of the protons and neutrons then present. If the early cosmos had been extremely dense, most deuterium should have been converted into helium, but astronomers have found this difficult to measure at distances beyond the Milky Way out in the distant (younger) universe.

A team led by Antoinette Songalla and her husband, Lennox Cowie, of the University of Hawaii using the 33-foot-diameter Keck telescope, which is perched atop an extinct volcano in Hawaii, have been able to measure deuterium at these distances by means of a study with the telescope's high-resolution spectrograph of a gas cloud backlit by a bright though even more distant quasar. Deuterium, like other elements, has its own spectral characteristics.

The team found a ratio of two atoms of deuterium to every 10,000 atoms of hydrogen. This ratio fits the Big Bang value and not the much reduced value expected for an extremely dense early cosmos. The numbers, obtained on a single night last November, were so unexpected that the Songaila team and others caution that they require confirmation by further observations.

If the findings hold up, they imply that the primordial soup was less dense with neutrons and protons (the components of ordinary matter) than expected, and therefore there is less ordinary matter in existence than previously thought. Specifically, the astronomers' report in 14 April *Nature* suggests that at least 99 percent of the mass in the universe is composed of unseen matter detected only by its gravitational influence.

Astronomers have long known that most of the universe is composed of unseen matter detected only by its gravitational influence. But they supposed that some of it was made up of ordinary "dark" (i.e. invisible) matter, such as dense but dead stars. The new findings would mean that astronomers have detected virtually all of the ordinary matter that exists.

Compton Data via Australia

NASA has opened a new, remote ground station in Tidbinbilla, Australia, called the GRO Remote Terminal System, to receive scientific data from the Compton Gamma-Ray Observatory (GRO) via a Tracking and Data Relay Satellite (TDRS-1) that was moved into position over the Indian ocean at 85°E from 171°W.

The decision to build the ground station and devote a TDRS to the Compton GRO came after the observatory's tape recorders failed, restricting transmission of scientific data to real time only. Since Compton was compatible with TDRS, this ground station option was feasible. An on-orbit repair of Compton GRO was an alternative, but would have been much more costly.

Work on the station began in September 1992 at an existing NASA site and was a cooperative effort between the Australian Space Office and NASA.

With GRO tape recorders not working, the observatory had been able to relay only slightly more than half of the data it collected, because it could not point at a TDRS at all times. With a TDRS devoted to Compton, scientists will be able to collect about 30 percent more. In addition, engineers will be able to keep better tabs on the health of the $500-million observatory, which was launched from the Space Shuttle Atlantis (STS-37) on April 5, 1991.

TDRSs receive data from Earth-orbiting satellites and re-transmit the data to a ground terminal in White Sands, New Mexico. Data from the Compton GRO will be relayed from TDRS-1 to Tidbinbilla to an Intelsat satellite to a West Coast location and then routed to White Sands. Control of TDRS-1 and this highly automated ground terminal remains at White Sands, New Mexico, marking the first time NASA is controlling an out-of-view TDRS from that location.

Space Probe Diary

29 March 1994

Galileo

The spacecraft is playing back data collected during the flyby of asteroid Ida in August 1993 at 40 bits per second. The image released on 23 March showing a small moon orbiting the asteroid appears on p.208. Galileo is 528 million km from the Earth and 622 million km from the Sun. It will go into orbit around Jupiter and relay data from a probe that will descent into the planet's atmosphere on 7 December 1995. The spacecraft condition is excellent, except that the high-gain antenna is still only partly deployed. The low-gain antenna is supporting communications, as it will for the Jupiter mission. Galileo was launched on 18 October 1989, flew by Venus in 1990 and the Earth in 1990 and 1992 for gravity assists, and flew by the asteroids Gaspra in October 1991 and Ida last August.

Magellan

The spacecraft remains in orbit around Venus between altitudes of 197 to 541 km, mapping the planet's gravitational field through precision tracking. This work is scheduled to continue until September 1994. The spacecraft's condition is very good. Magellan was launched 4 May 1989. It radar-mapped more than 98 per cent of Venus's surface between September 1990 and September 1992.

Ulysses

The spacecraft is in a highly inclined solar orbit, now 57.6 degrees south relative to the solar equator, and about 506 million km from the Sun. Ulysses will pass more than 70 degrees south on 27 June and reach 80 degrees south on 14 September 1994. The northern polar passage will take place in June to September 1995. Spacecraft condition and performance are excellent. Ulysses is gathering data on the heliosphere. The spacecraft was built by ESA and launched on 6 October 1990.

The New Hubble Space Telescope

The Hubble Space Telescope (HST) was launched in April of 1990. Two months after launch it was discovered that the 2.4m primary mirror had been figured incorrectly and, as a consequence, the telescope suffered from "spherical aberration". The resultant degradation of image quality blurred the capabilities of HST, particularly with respect to faint objects, but it was still able to carry out a meaningful programme of observations. Computer processing of the flawed images was effective in restoring some of the lost capability when bright objects were under observation. A shuttle servicing-mission in December 1993 has been spectacularly successful in clearing up the telescope's blurred vision and correcting a few other problems that had arisen.

The post-servicing complement of instruments consists of two imagers and two spectrometers, a quartet which analyses the light, from the ultraviolet to the near infrared, delivered to the focal plane by HST's optical system. (A fifth instrument, the High Speed Photometer was removed during the servicing mission to make room for some of the corrective optics). Three of the instruments, the European Faint Object Camera, the Faint Object Spectrograph and the Goddard High Resolution Spectrograph, are mounted directly behind the focal plane, while the Wide Field and Planetary Camera is mounted radially in the telescope, and light from the telescope is delivered to that instrument by a pick-off mirror.

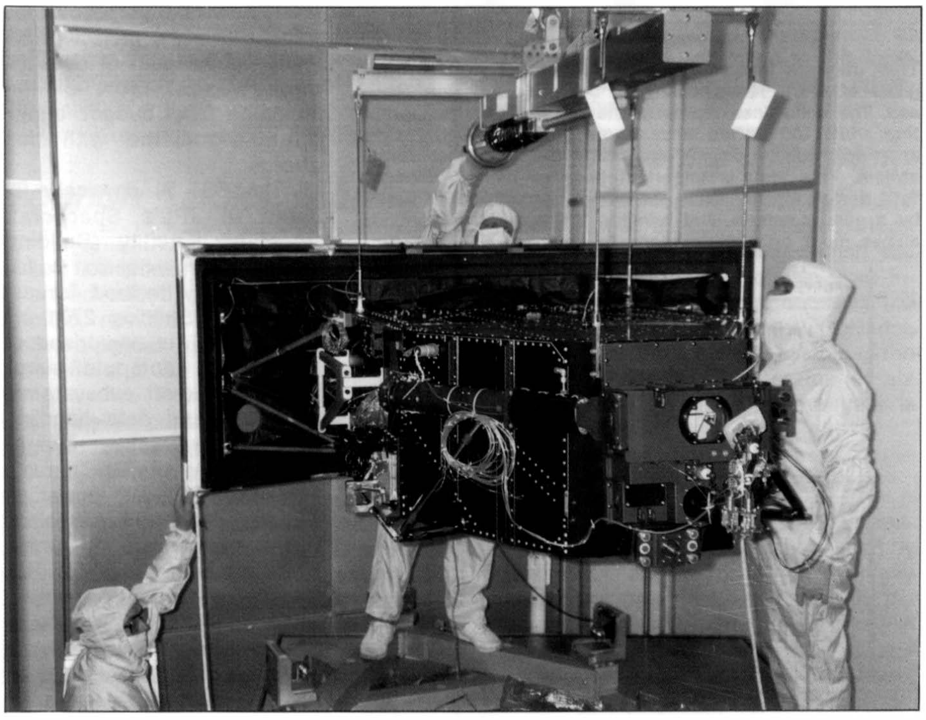
These geometric distinctions led to differing strategies for designing the optical fixes. The Wide Field and Planetary Camera (WFPC-I), while performing exactly as designed, was removed and replaced by a version (WFPC-II) of the instrument whose optical prescription compensated for the figuring defect in the primary mirror of HST. The three other instruments now receive input wavefronts as originally intended through the introduction, as a result of the servicing by the astronauts, of COSTAR (Corrective Optics for European Faint Object Camera and Spectrography) the device replacing the photometer.

Spacecraft systems which were in need of repair, as a result of degradation during the time since launch, were also fixed: three failed gyroscopes, jitter in the solar panels, etc.

The WFPC-I and WFPC-II instruments were designed and built by JPL, and I met with my colleague Larry Simmons, the Project Manager for WFPC-II, to discuss that effort. (His work as manager of the ATMOS mission was described in the June 1984 edition of this column.) A measure of the importance of WFPC-II in the observing programme of HST is supplied by the statistic that approximately 70% of the observing time will be used by this instrument.

Simmons was appointed to his present job, Manager of Planetary, Astrophysics, and Microgravity Experiments in JPL's Office of Space Science and Instruments, in February of 1990, prior to knowledge of the primary-mirror problem of HST. One of his tasks was to oversee the development of WFPC-II, an endeavour which had begun in Fiscal Year 1984. The original motivation for building a second WFPC arose from recognition of the fact that the first instrument, like all hardware systems, was subject to aging and, hence, would eventually have to be replaced.

Front view of the Wide Field/Planetary Camera-II which fits into a radial bay of the Hubble Space Telescope. The pick-off mirror is in the foreground, followed by the shutter. The photograph was taken before covering the outside of the instrument with multi-layer insulation needed for thermal control.



SPACE AT JPL

BY DR WILLIAM I. McLAUGHLIN
Jet Propulsion Laboaratory, California, USA

However, it was soon apparent that instead of producing a "clone" of the first WFPC, it would be cost effective to introduce some improvements into the design of the replacement instrument. The fact that WFPC-I was a product of the decade of the 70's (HST was to have been launched in the early 80's), and technology has advanced since then, plus experience gained during the development of the instrument made the conclusion plausible.

Simmons identified three primary actions to introduce improvements into WFPC-II: changing the set of filters; getting rid of a "light pipe" that was built into WFPC-I, using that area in which to install an internal calibration system for the camera; and, finally, to alleviate certain contamination problems.

The filter alteration derived from additional analyses of what wavelength ranges would best serve the scientific objectives. The light pipe routed UV photons from the Sun through a spacecraft radiator and saturated the charged-couple devices (CCDs) in the focal plane in order to, it was felt, improve the quantum efficiency of the CCDs; subsequent experience showed that this action was not necessary. Internal calibration would be accomplished by two visible-light lamps and a deuterium lamp for the ultraviolet calibration.

The alleviation of contamination was a big task and an important one; contamination is particularly damaging to observations in the ultraviolet.

The above considerations represent the state of affairs prior to the discovery of spherical aberration in the primary of HST. After that event, Simmons was directed by his management to concentrate all of his efforts on the adaptation of WFPC-II to accommodate the flaw in the primary mirror (as well as the above design improvements) and to complete the task in time for a shuttle servicing mission in 1993. Other responsibilities within his programme office were assigned for the time to another manager.

When I asked him what his principal challenges were, he listed six.

First, the optical prescription had to be made exactly right. The problem with the primary mirror of HST had to be understood and a robust correction introduced into the optical system of WFPC-II. The

details of this process have been described by Arthur Vaughn in the October 1989 issue of JBIS.

Second, in 1991 it was decided to employ new CCDs in the focal plane, and all the constituent changes had to be planned and carried out.

The decision to use "90's" CCDs in place of the "70's" CCDs in WFPC-I was not only based upon their increased capability, the uniformity of the field would be much greater, but also, and more significantly, their greater reliability. In addition, in order to lower costs, the format of the layout of the focal plane was changed, reducing the number of CCDs from eight in WFPC-I to four in WFPC-II.

A third challenge was to ensure the correctness of the optical alignment of the camera. Alignment would, of course, be important in any case, but the difficulty was increased for WFPC-II because the instrument was correcting for the spherical aberration of the telescope by introducing equal and opposite aberration.

Articulations, a pick-off mirror plus that of an articulating fold mirror, were designed to give the instrument enough degrees of freedom to be fully adjustable once in orbit. The provision was made in order to afford relief if the original alignment degraded as a result of the launch environment. (It did not degrade.)

Fourthly, cost and schedule were, not surprisingly, major challenges.

"Proving that we had done it" was included by Simmons in the list. In view of the nature of the problem with the primary mirror, it is also not surprising to see this item. The project was required to verify key points by two test methods, e.g., an interferometric method plus a method based upon ordinary geometric optics.

The sextet of challenges was completed by the observation that repair of HST was a highly visible project and, hence, subject to frequent reviews by a variety of boards. Supporting these reviews placed additional stress upon an already difficult schedule.

A perspective on the schedule can be gain by reviewing the chronology of major events. As mentioned, Simmons was appointed in February 1990, and launch was in April 1990. That summer, spherical aberration was diagnosed, and, by analysis and examination of diffraction patterns after commanded motions of the secondary mirror, the actual optical prescription of WFPC-II was deduced. The winter of 1990-1991 saw a consensus emerge as to the cause of the problem. In spring of 1991, a review was conducted as to how to proceed followed, in summer, by the dilemma of how to fix the problem in a fiscally constrained environment. In fall 1991, NASA set the date for the servicing mission and announced the cost-cap number.

NASA's Administrator, Daniel Goldin, has emphasized the value of conducting projects in the mode of "faster, better, cheaper." Considering the rapid chain of events, the WFPC-II effort certainly qualifies with regard to the first attribute. "Better" follows from a direct comparison with WFPC-I, and, we must grant the third attribute to this on-budget project.

Reengineering the Project Design Process

When the art of designing and fabricating interplanetary spacecraft was new, in the decade of the 60's, JPL practice was to build three spacecraft for a mission: two for flight and a proof test model (PTM). The PTM was the first of the three. Although it need not be built from space-qualified components, it closely resembled the flight models to follow and was used to work out technical problems. With the passage of time, the Laboratory gained experience in spacecraft design and eliminated the PTM, saving money, but still built two flight spacecraft. In the recent past, again to save money, not only the PTM but also the second flight spacecraft have been omitted. Now, however, as a result of a changing environment, JPL is rethinking its approach to building flight systems, "reengineering the process."

The two principal salients for this effort are a Flight System Testbed facility and a Project Design Center. Both are the responsibility of JPL's recently established Implementation Development Office, managed by E. Kane Casani. He and I go back a long way-I worked for him in the mid 70's when he was manager of the Infrared Astronomical Satellite (IRAS)-and we got together recently so that I could learn more about his work. Some of the results of this conversation are presented below.

Casani is well suited for his current assignment due to the experience gained from a long and distinguished career at JPL. Joining the Laboratory in 1958, he participated in the design and development of the early Mariner and Ranger spacecraft and had a leadership role in the Mariner 9 mission to Mars, the first planetary orbiter (1971). His management role in IRAS has been noted, and he has also managed the Observational Systems Division. Most recently, prior to his present assignment, Casani was the Manager of the Miniature Seeker Technology Integration (MSTI) Project at JPL, sponsored by the Strategic Defense Initiative Office. This highly successful project demonstrated new and innovative approaches to low-cost, rapid design and development of spacecraft.

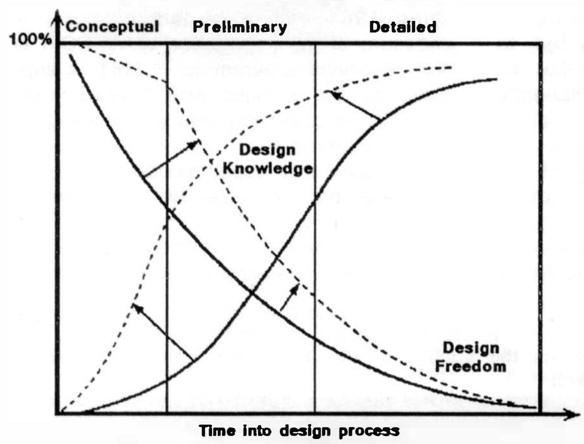
The taxonomy of possible flight-system simulacra begins at the low end with a "breadboard," a functional emulation used to bring out conceptual and design problems. The path then splits, leading either to a PTM or to a "protoflight unit." While the PTM is not intended for launch, the protoflight unit serves initially as a test unit and, after upgrade, becomes the actual flight unit. The protoflight approach is feasible in uses where the design is very well understood prior to initiation of the project.

Now, the intent is to have the Flight System Testbed (FST) serve the purpose of the PTM, allowing a project to follow a robust path of development without most of the schedule and budget agony often associated with this choice.

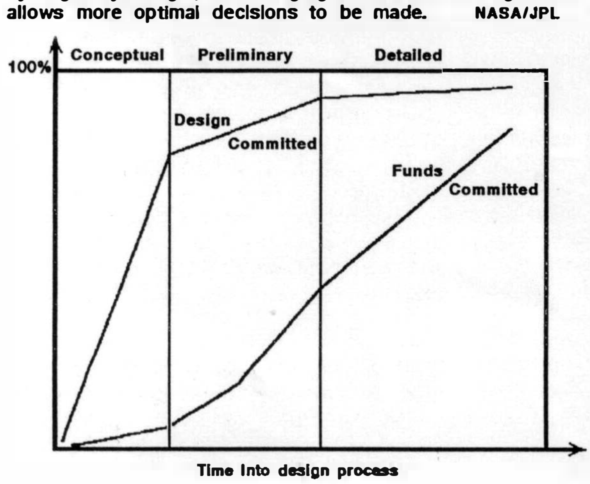
The FST is physically located in JPL's Spacecraft Assembly Facility (Building 179) with an extension to an interferometry testbed for astrophysics (Building 277).

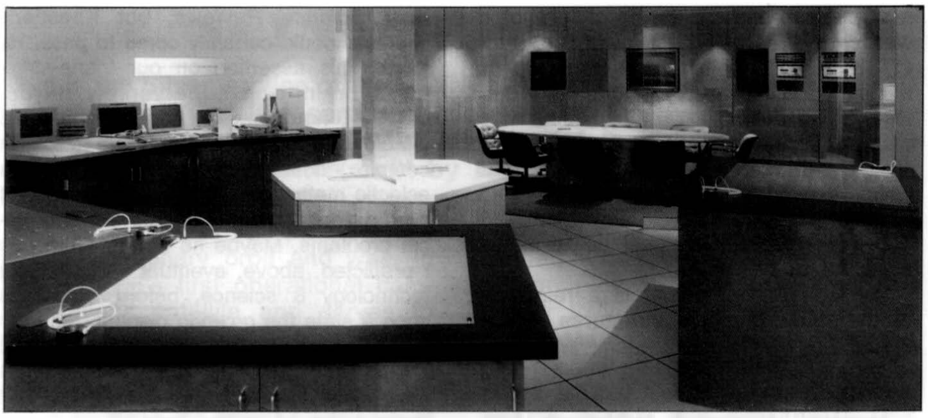
The FST is comprised of individual computer-simulated spacecraft subsystems: command and data handling (C&DH); guidance, navigation and control (GNC); radio frequency (RF); and power. In addition, there are provisions for a spacecraft dynamics simulator (SDS) which includes the attitude and articulation control (AACS) subsystem functions. The SDS is an all-software model and pipes AACS information (such as

Life Cycle Design Process



This diagram illustrates, in a conceptual manner, the goals of JPL's reengineering of the project design process. The solid lines represent the results of current practice while the dotted lines show goals. Earlier design knowledge allows design freedom to extend further downstream. This shift is important because the commitment to a design already leads the actual commitment of funds by a goodly margin, and bringing the two closer together allows more optimal decisions to be made. NASA/JPL





The new Flight System Testbed at JPL has three test stations and a network of computer workstations. NASA/JPL

changing voltages from the star tracker as it scans) to the GNC subsystem based on thruster firings and other events that influence the orientation of the spacecraft. The FST can accommodate a ground data system (GDS) and payload instruments.

As an example of function, the power supply provided by the FST is able to furnish the various voltages commonly utilized by spacecraft along with typical conditioning, e.g., square wave, and can even inject desired levels of noise into the power.

Projects can take advantage of the flexibility of the FST by supplying their own hardware to install into parts of the facility while utilizing existing FST simulations, tailored to the needs of each project, for subsystems for which hardware is not yet available. The FST can be used in an evolutionary fashion by successively installing breadboard, engineering, and flight units for subsystems, if desired.

The first customer for the FST, which itself started into development in late 1992, was the Mars Pathfinder mission. A breadboard version of the Rover (in effect, an instrument) to be carried onboard Mars Pathfinder was hooked into the FST and commands sent to that vehicle through simulations of the GDS and the RF and C&DH subsystems. Subsequently, the Pathfinder instantiation of the FST has evolved, with the maturing project, to include a breadboard of the RF subsystem and the project's C&DH computer.

The astrophysical interferometer, mentioned above, has received input in the form of stellar simulation from the FST, and the proposed Pluto fast flyby mission has become involved with the facility.

While the emphasis so far in this piece has been on the testbed, Casani said that the Project Design Center (PDC) is an indispensable key to the reengineering process. The intellectual root of the PDC grew from appreciation of the phenomenon that the effective commitment of funds through early, fundamental design choices is considerably in advance of the actual commitment of funds to implement the design in hardware and software. Thus, a stretch of time is created where new knowledge is irrelevant.

Reaching back to his experience with IRAS, Casani said very early choices had to be made with regard to: the cryogenic system (superfluid helium or a dual system with a Joule-Thompson cooler?); the material for the primary mirror (beryllium or glass?); and the diameter of that mirror. The choices that were made determined much of the subsequent course of the project, yet it was difficult to conduct enough tradeoffs to ensure that design space had been adequately explored prior to design commitment.

The approach to design that has dominated past projects has utilized the design-team method where subsystem experts periodically meet with system engineers to define problems and assemble a list of actions to be working during the next week or so. While this method has served the Laboratory in support of many successful missions, it is time consuming, report intensive, and meeting intensive.

In addition, the classical process tends to be sequential with the designs for the mission, flight-system, and operations proceeding in that order, followed by an estimate of the cost of the project.

An important feature to be recognized in the design process is that design in itself is a social function requiring face-to-face interaction between the participants. The PDC employs a collocated design team with multidisciplinary members and access to networked computer-aided design tools providing the social environment needed to more efficiently execute the design.

The goal is to reduce the time required for the project design process by a factor of two to three. Rapid iterations, with cost as one of the design variables ("design-to-cost"), enable concurrent, as opposed to sequential, design of mission/flight system/operations. The efficiency of the process yields a better product through a more comprehensive exploration of the design space, with cost built-in as a constraint, than its ponderous predecessor.

The PDC takes advantage of the latest advances in design software and computer systems, but it builds upon long established traditions. The process resembles the "skunk works" environment common to some large aerospace firms, and computer-aided-engineering/computer-aided-design (CAE/CAD) tools have been used for years to design subsystems.

From a large set of PDC capabilities, a few examples can be given: (1) trajectory, manoeuvre, and navigation analyses for the mission, (2) requirements management, telecommunications analysis, and cost estimates for the flight system, and (3) telemetry data-flow simulation, downlink and uplink operations process development, and documentation preparation for the mission-operations system.

A crucially important component of JPL's conduct of business is the system contracting of missions to U.S. industrial firms. Here, the PDC can be used for feasibility studies and cost estimation during preproject phases. After selection of an industrial contractor, the PDC, electronically connected to the home institution, may still be utilized by the contractor with detailed subsystem design being performed at the contractor's location. If the contractor has a similar design centre, the two could be interfaced for design reviews; the PDC will use industry standards for data exchange, computer-generated models, and data bases.

The testbed and the design centre, as they grow and experience is gained with their joint use, represent a significant increase in the Laboratory's capabilities.

Zones of the Future

Predicting the future is a human activity that, in general, has had little success. Amelioration of the difficulty of providing reliable forecasts has been achieved through considering only highly structured situations, or limiting projections to the near future, or sketching only general patterns. The conduct of a space programme is intertwined with "futurology." Reliable planning of programmes needs an estimation of future states: scientific technological, and cultural. Also, space exploration is by its nature a future-oriented activity, and, so, probing the future yields insights into the possibilities and threats which face our discipline. The approach in this piece is to look forward by utilizing two of the three techniques: structure and generality. I have had the temerity to ignore the middle technique and, in fact, have ventured into the distant future.

The particular structure I have in mind is to employ the idea of progress, or its lack, to provide the measure of future states, i.e., "progress" is the substance whose quantity is to be predicted. (I use "substance" in a metaphorical sense; it seems to facilitate discussion.) Generality enters through characterizing progress only in terms of what I call "zones of the future": a coarse resolution whose potential zones are progress *per se*, decline, stasis, and cyclic variation.

The surge of science and technology in the last few centuries has made progress, of one sort, seem inevitable to us, but the concept of progress as a significant component of civilization is relatively new; the eighteenth-century Enlightenment is an important wellspring if we are to believe the historians. (See J. B. Bury's *The Idea of Progress*, 1932 (Dover reprint 1987), and two articles on the topic in Volume III of the *Dictionary of the History of Ideas*, Philip Wiener, ed., Scribner's, NY, 1973.)

As a counterpoint to progress, tales of decline from a golden age through a silver age and into subsequent metallurgical dregs are not uncommon: Ovid's (43 B.C.-17 A.D.) charming *Metamorphoses*, for example, posits this doctrine.

Animal species are generally observed to be in a state of stasis with respect to most benchmarks of progress so it is not unreasonable to expect that our species may eventually attain such an equilibrium state. In fact, there are some theoretical indications that point in that direction. As I mentioned in the October 1993 edition of this column, Martin Harwit has asserted that the total number of major astronomical discoveries is ultimately limited, and astronomy will be exhausted as a topic in a few hundred years. (However, in trying to express this view, I butchered the syntax. A sentence on page 360, in the last column, is one I have been eager to revise and do so here: "Martin Harwit ... contends that the number of major astrophysical discoveries that *can ever be made* is modest, and we have already achieved a nontrivial fraction thereof.") An analogous process has already run its course with respect to knowledge of the physical geography of Earth.

The fourth zone, cyclic variation, has been, like decline, a popular motif throughout the ages; the Greeks and the Romans were particularly fond of it, and Plato developed a cyclic theory of rise and fall (with a period of 72,000 years).

Of course, the four zones are a rather simple-minded schema, and they can be combined to yield more complex structures. For example, the historical model proposed by the Italian philosopher Giovanni Vico (1668-1744) can, according to Bury, be characterized as an ascending series of cycles, i.e., zone 1 modulated by zone 4.

Progress, as conceived here, is not a totally simple substance. There are, as mentioned above, at least two principal components: science & technology and a cultural part. Certainly, the two types have and might be expected to continue to evolve at different rates.

I expect only zone 4 behaviour, cyclic variation, with respect to the cultural component (or zone 3, if coarser resolution is applied). This is not an optimistic conclusion, but it could be worse: decline. My conclusion is based on history and biology. The social and moral content of our civilization, in my estimate, has gone through a series of ups and downs, with no overall indication of a trend in the historical record. To be sure, sunny periods appear and contemplation of them may inspire optimism. In the often quoted words of the historian Edward Gibbon (1737-1794), "If a man were called to fix the period in the history of the world during which the condition of the human race was most happy and prosperous, he would, without hesitation, name that which elapsed from the death of Domitian to the accession of Commodus." (96 A.D.-180 A.D.) But contrast this with the slaughter of World War I.

My biological comment is a reference to the more primitive structures in our brain, e.g., the limbic system, which affect behaviour and do not seem to be educable.

However, science & technology, having been ignited, should be, in the absence of social collapse, headed upward in zone 1 fashion until the natural limits of our species are encountered.

One indication of such limits was given, for a special case, by mention of Harwit's results. More general reasons have been put forth by the linguist and cognitive scientist Noam Chomsky, among others. Chomsky, over the years, has championed innate biological processes as the source of much of our ability to learn language. This genetically based explanation can be opposed to, for example, a theory of language learning which is heavily dependent on cultural ingredients. He says that we are good at language because we have been "wired" that way, courtesy of biological evolution.

Chomsky has speculated - his 1976 book *Reflections on Language* is a good source - that biology may underlie other cognitive functions such as the capability to do science. If this is true, a corollary is that there are domains where our science can never penetrate because of our biological limitations (rather than a cognitive model where, given enough time and effort, we will learn all there is to know).

I subscribe to this theory of limitation except I could not, for a long time, see how the subject of mathematics could be bounded: it seems so limitless. However, after reflection, I believe that the problem humans will face is comprehending the statement of very long theorems, and not necessarily our inability to prove theorems. That is, with a finite alphabet of symbols, we will eventually explore all of the interesting short theorems and then be forced into attempting to digest huge statements. The formulation of a large theorem, unlike its proof, which can be sequentially assimilated, at least in principle (although some computer-generated proofs are stressing such a contention), could be very difficult to understand as to its import and significance.

In summary, then, I see stasis in both components: culturally we are now in that state and we will eventually enter it with regard to science & technology. The remaining question is: what will be the final disposition of our species? More specifically, is our species a dead end, as the writer Arthur Koestler (1905-1983) believed, or will we leave evolutionary descendants?

I have argued the latter position in a paper in the December 1983 *Interdisciplinary Science Reviews*, but Koestler's scenario could certainly come to pass. He founds his assertion on our triune-structured brain which, perversely, layers cerebral functions on top of emotional (limbic system) and aggressive (reptilian complex) domains. Koestler said that this eclectic method simply does not work and has produced unresolvable psychological problems. Maybe he is right. Although I predicted, above, eventual stasis for our technology & science, before it reaches such a state the growing disparity with our cultural component may be so great as to rip us apart. An asteroidal impact may have killed the dinosaurs, and the lack of appreciation of poetry may kill us.

When might our species terminate (leaving descendants or not)? There is a line of thought, statistical in nature, which has been developing for a few decades now and appears in discussions on the "anthropic principle" or, sometimes, in theoretical discussions on the prospects of the search for extraterrestrial intelligence. A first-rate representative of this school is Richard Gott's paper in the 27 May 1993 issue of *Nature*.

The essence of his hypothesis is that, statistically, as observers, we are unlikely to be positioned in the early or late stages of a temporally enduring event: a magazine's span of publication (***Spaceflight*** is 38 years old so it is likely to last a similar amount of time); a nation (the U. S. is over 200 years old so it should have centuries ahead of it); or a species (humankind probably has hundreds of thousands to millions of years ahead of it.) The arguments are more sophisticated than my brief statement; I urge you to dip into this fascinating paper.

However, I do believe that the arguments of Gott, when they treat events more than a few thousand years in the future, are in need of revision from the simple form he has cast them. In brief, my concern is that the time scale exceeds the limits of the epistemological assumptions which he has incorporated in his model. The subjects of evolutionary biology, cosmology, and, indeed, our whole world view are changing with extraordinary rapidity. Bury makes the point, in his conclusion, that the very idea of progress will probably be subsumed under another rubric.

Consider, say, the Neanderthal view of the world, current only a few thousands of years ago. Even though the statistical principles Gott employs can be granted permanence, the domain in which they would have been applied, which featured mammoths and ice, is far removed from the cosmos of the Big Bang. The fundamental predictions that could have been made by a mathematically precocious Neanderthal would be untrue or irrelevant today.

My guess, and it is only a guess, is that the progress of science & technology, particularly in computers and genetic engineering, will for better or worse produce a new species in a relatively short period of time. That is, contrary to Gott's view, we are near the end of an epoch. I hope this new species does better with regard to its appreciation of poetry. ■

BIS President 1994-95

Dr Paul Thompson. Courtesy SHEILA BURNETT

We are pleased to record that Dr Paul Thompson was elected President of the Society for 1994-95 at the Council Meeting in April. He succeeds Mr Anthony Lawton who automatically retired at that meeting on completion of three consecutive years in office.

Paul Thompson was elected to Council in 1990 and served on the Society's 60th Anniversary Committee and subsequently on the Council Advisory Committee on Space Policy and Technology. During the last year he has been Chairman of the Programme Committee.

His specialist field is that of communications satellites which he studied for his PhD degree when he carried out propagation measurements with the ATS-6 satellite in 1976. From the following year he was involved with NATO satellite communications at the SHAPE Technical Centre in the Netherlands, returning to England in 1981 to a post in the satellite system division of the Post Office, which subsequently became British Telecom. He was the first UK representative to hold the position of international chairman of the INTELSAT Board of Governors Technical Advisory Committee and has been a delegate at several World Administrative Radio Conferences (WARC's) which manage the allocation of the radio frequencies and orbits for communications satellites.

He is currently Manager, Technology and Development, Global Networks Directorate, BT plc.

In accepting office, the President said that the Society had for a long time been at the forefront of pioneering ideas for space exploration and development, of which Arthur C. Clarke's proposal for communications satellites in geosynchronous orbit had been one of many.

"The Society needs to continue to fulfil this role as new technologies emerge and, at the same time, to continue to work on the wider front of promoting public awareness in space and in furthering space education for younger people", he said, adding that "With our active programme of publications and meetings, the Society is well placed to do this".

At the same Council meeting Mr Martin Fry was re-elected Vice-President for a third consecutive year. Martin Fry graduated from the School of Mechanical Engineering, Cranfield in 1971, returning to Rolls-Royce to work there in the Future Projects Department. He subsequently moved to British Aerospace and then to W.S. Atkins Engineering Sciences, where he became Managing Director. In 1991 he set up his own Energy Consultancy and specialises in fuel cell technology along with more general interests in the energy field.

Also elected Vice-President was Mr John Harlow, who is Chairman of the Society's History Working Group. His specialist field is that of rocket propulsion technology being a graduate in Applied Chemistry and holding a Masters degree in Astronomy and Astronautics. From 1972 to 1986 he was a design engineer at Hunting Engineering and since 1986 has been Manager, Systems Support Group, Royal Ordnance Rocket Motors Division. He succeeds Mr Rex Turner who retires on completion of three consecutive years in office as Vice-President.

Apollo 11 Lunar Module Team Manager

Ross Fleisig.

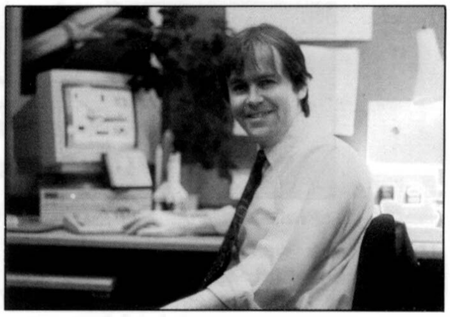
With the approach of the 25th anniversary of the Apollo 11 mission and first manned landing on the Moon, we are particularly delighted to hear again from Ross Fleisig who is President of Therus Dynamics, Inc., an aerospace systems consultancy in New York, USA.

From 1961 to 1984, Ross was employed by Grumman Corporation and was closely associated with the Apollo program and the Lunar Module in particular. He was Spacecraft Team Manager for the Apollo 11 Lunar Module being responsible for its final assembly and test at the factory and at the NASA Kennedy Space Center. Subsequently he became Head, Apollo Lunar Module Dynamics and Performance Analysis.

Later this year, Ross Fleisig will be talking about his Apollo 11 work at an evening meeting of the Society. An announcement appears on the inside back cover.

Ross Fleisig (centre) in front of the Apollo 11 Lunar Module No. 5 Descent Stage in December 1968.

Science Museum Appointment



Doug Millard.

Our hearty congratulations go to Doug Millard, who is a member of the Society's History Working Group, on his recent appointment as Associate Curator for Space Technology at the London Science Museum where he has worked for the last nine years.

Doug writes to say that for the last twelve months he has been coordinating the implementation of a new computer network and anticipates considerable changes in the way we collect, interpret and display museum artifacts:

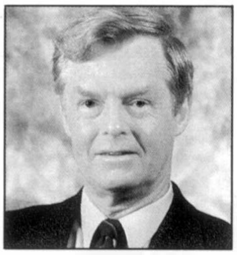
> "The information technology revolution is affecting museums just as much as everywhere else. We must be aware that vast amounts of high class data are literally available at our finger tips and that much of these will soon be readily accessible in the home. The challenge facing museums is to incorporate these technologies along with the fascinating and unique collections which they hold. There is only one way to appreciate the aura of the Apollo 10 Command Module - the second spaceship to take human beings away from Earth - and that is to stand next to it in the Science Museum!"

When last working with the Space Technology collection he arranged several exhibitions including "Spaceplanes", "ERS-1" and a collaborative display with the Japanese Space Development Agency:

> "This was a particularly challenging project as we had to bring a full size LE-5 rocket engine through a narrow portion of the "Exploration of Space" gallery. After numerous telephone and fax conversations with NASDA I was satisfied that we could theoretically do it with a hair's breadth to spare. I am happy to say that NASDA's dimensions were spot on and the engine slid past Black Arrow with just 10 mm separating the two!"

Besides developing the Science Museum's collection, Doug's time will also be spent researching the history of Space Technology. In October 1992 he presented an evening lecture to the Society on the history of spaceplanes which appeared as an article in ***Spaceflight*** in March 1993.

New Research Council Head



Prof. Ken Pounds.

The Society welcomes the recent announcement that space physicist and astronomer Prof Kenneth Pounds of the University of Leicester has been appointed the first Chief Executive of the newly-formed Particle Physics and Astronomy Research Council (PPARC).

PPARC and the new-formed Engineering and Physical Sciences Research Council (EPSRC) now replace the former Science and Engineering Research Council (SERC). PPARC has responsibility for allocations of funding for research and training in fundamental science - the origin and formation of the universe and the forces that govern it, the nature of matter itself, the Solar System, the Sun and planets and their interactions.

Ken Pounds is a member of the International Editorial Board of JBIS (Journal of the British Interplanetary Society) and last year gave an evening lecture to the Society on the "Development of X-ray Astronomy in the UK", a report of which appeared in the March 1993 issue of ***Spaceflight***.

JBIS Papers

We note with pleasure that a paper published by the Society in ***JBIS*** has been selected for inclusion in an anthology of outstanding papers on the topic 'Cryogenic Optical Systems and Design Consideration'. The paper concerned is "NICMOS: The Near Infrared Camera and Multi-Object Spectrometer for the Hubble Space Telescope" by R.I. Thompson.

The anthology is to be published by SPIE, a nonprofit society dedicated to advancing the engineering and scientific applications of optics, and is due to appear this Summer.

Many other ***JBIS*** papers are recognised as being of such high merit that requests are made for them to be further reproduced in other magazines. The most recent is the paper by Dr McLaughlin on "The Potential of Space Exploration for the Fine Arts" which appeared in the November 1993 ***JBIS*** and is now scheduled to be reprinted in *Leonardo*, a magazine devoted to the Arts.

Society Development Appeal

1993 saw the completion of the final main stage of construction at the Society's Headquarters.

The fact that so much was achieved over the last five years is due in no small part to the extra income that came to the Society by way of donations and general fund-raising.

With our regular income needed for ongoing member services, the part played by this extra income is vital to enable the Society to play a developing role in the promotion of space exploration and development.

Our Development Appeal Fund was re-established from 1 January 1994 to be applied for purposes of expanding the Society's activities. The fund has already benefited from the donations made by members when returning their 1994 Renewal Forms and the Society has taken the opportunity to invite support from other quarters during 1994.

There is much that awaits the Society to do to augment its future work, but what can be done and how soon depends largely on the financial resources at its disposal. Members are asked to keep these needs in mind and to help whenever possible either directly or through contacts and opportunities that may come their way.

Donation from British Telecom

The Society gratefully acknowledges the receipt of a donation of £4000 from British Telecom towards the cost of printing two space education booklets.

Gift Aid

Gift Aid is a UK tax concession that allows individuals and companies to make single gifts to the Society with the benefit of tax relief. There is a statutory minimum limit of £250 but no effective upper limit.

Administratively, the scheme is straightforward with a single form to sign, which the Society will gladly provide.

Gifts to the Society

From time to time the Society receives valuable support in the form of a bequest. A simple clause in either a Will or Codicil is all that is needed to make such an arrangement, e.g.

'I give, devise and bequeath to the British Interplanetary Society Limited of 27/29 South Lambeth Road, London SW8 1SZ the sum of £.... (followed by the amount in words) free of all duties'.

The Executive Secretary will be pleased to supply more detailed information on request.

Spaceflight Crossword

No. 10

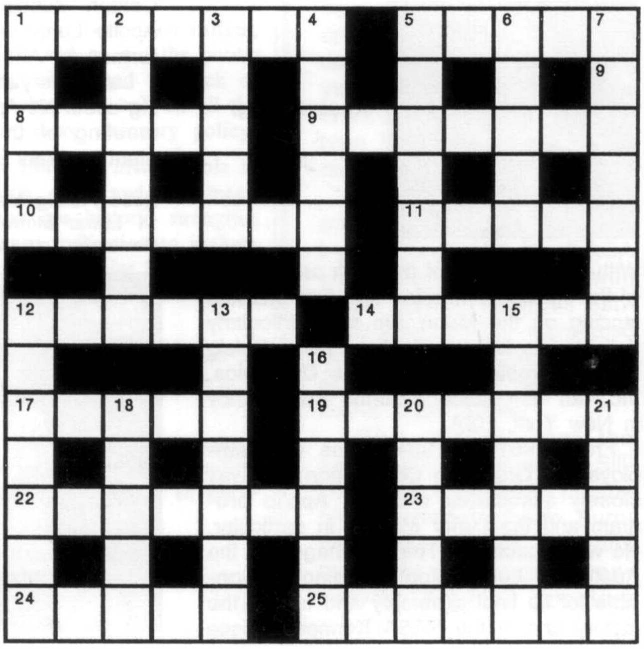
ACROSS

1. Modified Vostok spacecraft
5. Cunning space vehicle ?
8. Free-wheel by seashore ?
9. Oozing out like a slow fuel leak
10. Effluent
11. Mosses to the taxonomist
12. Occurrence between day and night
14. Not celebrated in song
17. Stir up
19 CIS member
22. Outermost
23. Incline
24. Used up
25. Satellite that makes Sam tire

Solution will appear in the July issue.

DOWN

1. In ——— (Latin)
2. Hardy payload for Shuttle release and retrieval ?
3. Spaceplane
4. Repudiate
5. He works aboard the Space Shuttle ? (4,3)
6. Sign of the zodiac
7. Pulling forcibly
12. Constellation
13. Beseech
15. It suits the military alike
16. ESA payload retrieved by Shuttle mission STS-57
18. Loosen
20. X-ray satellite
21. One for one money-wise



Solution to Crossword No.9.

ACROSS: 1. Twist; 4. Drill; 10. Fortune; 11. Aural; 12. Eject; 13. Ulysses; 15. Lisa; 17. Amber; 19. Raise; 22. Aide; 25. Largest; 27. Rebel; 29. Nouns; 30. Habitat; 31. Tyres; 32. Aches. **DOWN:** 2. Worse; 3. Shuttle; 5. Ready; 6. Lyrists; 7. After; 8. Venus; 9. Close; 14. Lard; 16. Iras; 18. Mercury; 20 Aerobic; 21. Elint; 23. Itchy; 24. Pluto; 26. Ensue; 28. Bathe.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: All Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Admission is by ticket only. Members should apply in good time enclosing a sae. Subject to space being available each member may also apply for a ticket for one guest.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight/JBIS*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

1 June 1994 — 7 - 8.30 pm

The Microlight Solar Sail

C. Jack

Recent advances in microelectronics make possible a new solar sail concept: a tiny rigid sail just a few metres in diameter which could be controlled purely by electronics, without moving parts.

The craft will be highly manoeuvrable, compared to a large sail, and will be capable of some ambitious missions, including rendezvous with near-Earth asteroids.

6 July 1994 — 7 - 8.30 pm

Life Support in Space and Lessons for Earth

R. Huttenbach

The talk will describe the features of systems used to sustain astronauts when they live in space.

The technology of biological life support and the evaluation of how closed a system should be, or can be, provide important insights into how we might use resources on Earth.

7 September 1994 — 7 - 8.30 pm

What Must We Change For Low Cost Space: Management, Politics or Technology

C.J. Elliott

Early space programmes were cheap and effective, whereas a mission like Envisat takes 15 years and costs 1500MAU. This lecture examines the drivers that force up the costs of space missions and seeks different ways of behaving that might lead to a virtuous spiral of falling costs and shorter development programmes.

6 October 1994 — 7 - 8.30 pm

The First Manned Lunar Landing Spacecraft: Its Design, Manufacture, Ground Test and Mission

R. Fleisig

The Apollo 11 space vehicle is described with emphasis on Lunar Module 5 (LM-5). Development tasks, including test articles and facilities are explained. Manufacturing flow and extensive ground testing phases are detailed. Finally the mission itself with the LM trajectories, important events and key astronaut activities are reviewed.

First Announcement

Hubble Repair Mission Astronaut
Claude Nicollier

at

The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1

on

Saturday, 27 August 1994

The Society is arranging a special meeting at which ESA Astronaut and BIS Fellow Claude Nicollier will talk about his work to members of the Society.

Further details will appear in a forthcoming issue of *Spaceflight*.

2 November 1994 — 7 - 8.30 pm

Chinese Space Programme

P. Clark

Interest in China's low-key space programme has increased since the mid-1980s when Chinese launch vehicles were offered for commercial use, as was space on their recoverable satellites for microgravity experiments. Phillip Clark, who has followed the Chinese space programme since its first satellite launch, will review the programme's history, look at the current status of the programme and try to predict in which directions we can reasonably expect the programme to continue.

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

APOLLO 11
25th Anniversary Celebration

at

The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1

on

13 July 1994 at 6.30 pm

The Society is to mark the occasion of the first manned landing on the Moon twenty-five years ago with a special evening buffet reception in collaboration with Cray Electronics plc.

Admission is by ticket available in advance from the Society: Price £15.00. Accommodation is limited and admission is restricted to members of the Society. Tickets will be issued on and after 20 June 1994. If the number of applications exceeds the accommodation available, allocations will be by lottery.

SYMPOSIA & CONFERENCES

4 June 1994 — 10-4.30 pm

Soviet Astronautics

Papers to be presented at this Symposium include: 'Submarine Launched Ballistic Missiles', 'Space Debris', 'Baikonour: a Personal Visit', 'The Far East Cosmodrome', 'Current US/Russian Manned Spaceflight Operations', 'Organisation of Cosmonaut Training Center', 'A Cosmonaut Update'.

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23 June 1994 — 10-4.30 pm

Space Industrialisation as a Response to Global Threats

Papers to be presented at this Symposium include: 'Space Industrialisation as a Response to Global Threats - An Overview', 'The Exploitation of the Moon to Substitute Terrestrial Resources', 'Sub-Orbital Tourism - The Key to Space Industrialisation', 'The Space Option and Our Future: Some Considerations on the Thermal Burden'. (See also p.205).

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29 August - 1 September 1994

Practical Robotic Interstellar Flight: Are We Ready?

Venue: New York City

New York University (9am - 5pm on four days)
The UN (evening 30 August) (*provisional*)

Technical Sessions

1. Interstellar Flight Concepts
2. Spacecraft Engineering Considerations
3. Extrasolar Planetary Systems
4. Intermediate Prestellar Destinations

Cosponsored by the Society (from whom further details may be obtained) in conjunction with 11 other organisations.

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15 September 1994 — 10-4.30 pm

Space Transportation and Infrastructure

This one day symposium will include papers on 'The Skylon Spaceplane', 'The Architecture of the Space Infrastructure with Advanced Spaceplanes'.

9-14 October 1994

45th IAFCongress
"Space and Cooperation for Tomorrow's World"

The 45th Congress of the International Astronautical Federation will be held in Jerusalem, Israel, October 9-14, 1994. There are 98 technical sessions planned. Details of the Programme are available from the Society. Please enclose a 19p stamp.

Society Symposia

Advance Registration is necessary. Limited undergraduate student concessions available on request. **Registration: Forms are available from the Executive Secretary. Please enclose a sae and indicate the Symposium you wish to attend.**

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Spaceflight

The International Magazine of Space and Astronautics

To the Moon

25th

Anniversary of the First Manned Lunar Landing

Plus:

Opening Up the Space Frontier with Single-Stage Rocket Technology

Space Launches

Astronomical Notebook

Outer Solar System

ISSN 0038-6340

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The BIS is proud to offer a stunning record of man's exploration of space brought to your home on video.
All videos are extracted from original footage.

NEW TITLES

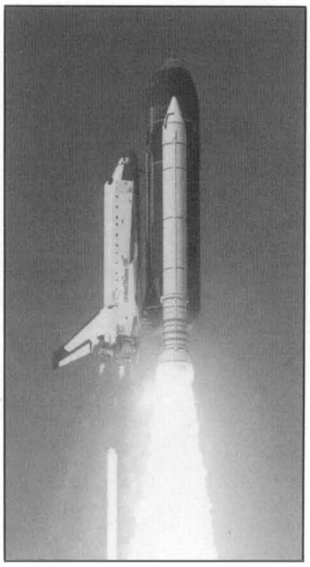
STS-57 : Mission Highlights

Raw footage with titles only and minimal soundtrack featuring the Endeavour launch on a 10-day mission on 21 June 1993 with a crew of Grabe, Duffy, Low, Sherlock, Wisoff and Voss. The flight featured experiments with Spacehab, a pressurised module attached to the orbiter middeck by a short pressurised passage, carrying over 20 different experiments in locker-type drawers.

Its other payload, which was recovered from space after almost a year investigating materials microgravity research, was ESA's Eureca satellite, deployed by STS-46. The remote arm was successfully used to grab the satellite and draw it into Endeavour's payload bay for return to Earth.

59 mins

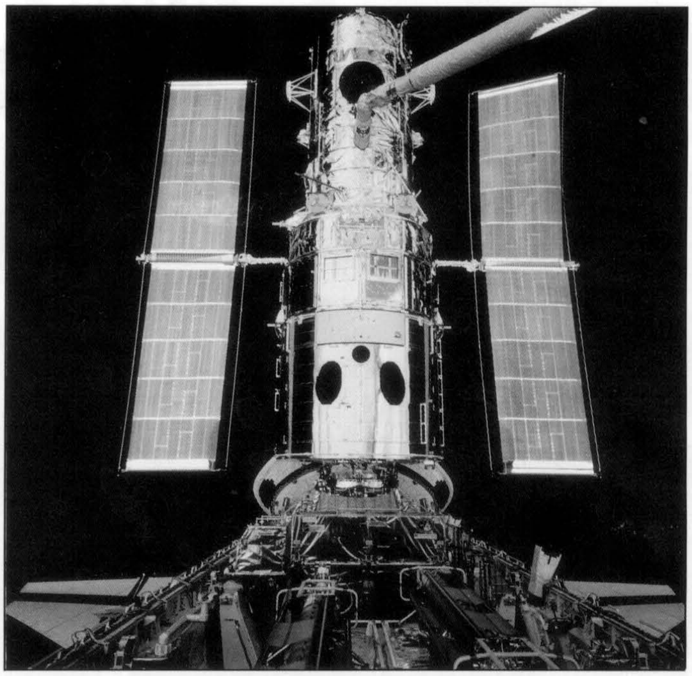
STS-58: Mission Highlights



Raw footage with minimal sound track of the "third time lucky" launch of Columbia on 18 October 1993 into its record-breaking 14-day flight during which the crew of seven (Blaha, Searfoss, Seddon, McArthur, Wolf, Lucid and Fettman) conducted a multitude of studies with the Spacelab Life Sciences 2 Module.

The main emphasis was on metabolic and cardiovascular studies to see how microgravity affects the human body. Various levels of exercise were carried out, using a stationary bicycle ergometer. Scenes were taken for an eventual educational film on the life sciences.

59 mins



Hubble Repair Mission

STS-61: Mission Highlights

Raw footage with minimal soundtrack of STS-61 launched on 2 December 1993. This 11-day flight was a major mission by Endeavour and its crew of seven (Covey, Bowersox, Musgrave, Hoffman, Akers, Thornton and Nicollier) to repair the faulty Hubble Space Telescope. Features spectacular EVAs. Major elements included changing the solar arrays and replacement of the Wide Field Planetary Camera with one which corrected the Hubble Mirror by reconfiguring the relay mirrors.

Work on the Telescope was likened by the crew as akin to "eye and brain surgery in space". The first response by astronomers to the successful mission was "Hubble Trouble is Over!".

2 hours

❑ STS-57 Mission Highlights	£15	(US$27)
❑ STS-58: Mission Highlights	£15	(US$27)
❑ STS-61 Mission Highlights	£18.50	(US$34)
❑ Space Shuttle: A Remarkable Flying Machine	£11	(US$20)
❑ STS 41-C: The Repair of Solar Max	£15	(US$27)
❑ Space Shuttle Challenger: Accident Investigation	£11	(US$20)
❑ STS-26: The Return to Flight	£15	(US$27)
❑ STS-31: The Hubble Deployment	£15	(US$27)
❑ STS-32: The Recovery of LDEF	£15	(US$27)
❑ STS-37 Video Highlights	£15	(US$27)
❑ STS-37: Post-Flight Press Conference	£15	(US$27)
❑ STS-46: Mission Highlights	£15	(US$27)
❑ STS-49 Mission Highlights	£18.50	(US$34)
❑ STS-49 Post-Flight Press Conference	£11	(US$20)
❑ STS-54: Mission Highlights	£15	(US$27)
❑ Time of Apollo	£11	(US$20)
❑ The World Was There	£11	(US$20)
❑ Skylab: The First 40 Days	£11	(US$20)
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❑ Mission of Apollo-Soyuz	£11	(US$20)

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Spaceflight

The International Magazine of Space and Astronautics

Published By The British Interplanetary Society

Vol. 36 No. 7 July 1994

To mark the 25th anniversary of the first manned lunar landing, Spaceflight presents:

TO THE MOON

Single-Stage Technology

Features

News & Events

Space Miscellany

Front Cover: **Buzz Aldrin descends the steps of the Lunar Module as he prepares to walk on the Moon. This photograph was taken by Neil Armstrong with a 70 mm camera during the Apollo 11 EVA on 20 July 1969.** **NASA**

Space Policy for Opening Up the Space Frontier

Single-Stage Rocket VTOL

The prime obstacle to opening up the space frontier on a grand scale is our continued dependence on the 'only to be used once' space launcher. Ideas and proposals for non-expendable space launchers have been around for some time. Operationally very attractive, but technically very demanding, is the Single-Stage-To-Orbit (SSTO) vehicle.

When tests took place last year with the 1/3-scale experimental McDonnell Douglas Delta Clipper (DC-X) at White Sands, the successful vertical take-offs and landings seemed to some to mark out the shape of things to come. *(See **Spaceflight**, March 1993, p.90, November 1993, p.378, December 1993, p.431).*

Orbital flight, or even great altitude, was not the aim in these first tests; just a lowly 1200 feet. But the demonstrations were enough for the technically-minded, including a number of ***Spaceflight*** readers, to weigh up future prospects and express their hopes (or doubts) about where it might lead. In the immediate short-term, it led to a lack of funds and a halt being called to the flight tests.

In the last issue of ***Spaceflight*** it was briefly announced that the White Sands flight tests were planned to resume in June. *Paul Blase* of Virginia, USA now sends details about recent developments:

Artist's impression of the Delta Clipper Single-Stage-to-Orbit spacecraft on the launch pad. MCDONNELL DOUGLAS

The last flight of the DC-X was on 30 September 1993. Shortly thereafter, the programme ran out of money, and BMDO (Ballistic Missile Defense Organization) was forced to postpone any further testing. At nearly the same time, the management of the DC-X program was moved to the Advanced Research Projects Agency (ARPA), which ran the programme through the existing BMDO management structure. Unfortunately, for a variety of reasons, ARPA was not particularly interested in SSTO technology and stalled further testing despite direct orders from the Congress to resume as soon as possible. Congress had even allocated the money, ARPA simply refused to spend it!

A considerable amount of lobbying by various individuals and space advocacy groups convinced the powers that be to cough up $990,000 to keep the DC-X in mothballs pending further action - enough money to keep the flight team together and the hardware in decent shape until April of this year. Finally, after more hard lobbying, we finally got the word on 3 May that ARPA had released $5 million to resume flight testing. The new flight sequence, which should consist of somewhere between three and five flights, is due to begin in early June. These flights will take the DC-X to above 20,000 feet and will practice the rotation manoeuvre necessary to move from flight to hover during the landing process.

Instead of going directly to the DC-Y, current plans call for the construction of the SX-2, an almost-orbit-capable prototype that builds on the DC-X. The SX-2 is intended to push the flight envelope still further as well as testing the use of advanced composites, which were not heavily used in the DC-X.

Congress has allocated an additional $35 million to begin work on the SX-2. Unfortunately, there is some considerable argument as to who exactly will be managing the SX-2, ARPA or NASA, and some reluctance to actually spend the money. NASA has expressed considerable interest in SSTO launchers, but indications are that it wants to turn the SSTO program into a "National Project", on the order of the Shuttle program, which would cost billions and *may* deliver a vehicle by 2010.

Official go-ahead for the SX-2 is still waiting on the release of two Congressionally-mandated future US space launch studies: The Defense Department's "Moorman Report" and the White House OSTP's (Office of Science and Technology Policy) "National Space Transportation Strategy". Both documents are considerably overdue. It is too early to try and guess what will happen next, but space advocacy groups are already initiating extensive efforts bent towards influencing the outcome.

The suggestion that the DC-X design might function as a hypersonic sub-orbital spaceplane has been sent to us by Ms *Nienna Tromlin* of Bristol, UK who writes:

I have been following with interest the various articles that have been published in ***Spaceflight*** concerning the DC-X experimental launch vehicle.

Invariably, the coverage has dealt with the vehicle's potential as a space launch vehicle, but I would like to suggest that with some modifications, the design would also function as a hypersonic sub-orbital spaceplane.

When taken in tandem, the celebrated gimballed engines of the DC-X and the kind of fly-by-wire and computer technology that have allowed us to expand our knowledge of aeronautics into the area of the flight characteristics of unstable aircraft, mean that we are (hypothetically at least) no longer restricted by the necessity to have wings on a sub-orbital spaceplane (as in the HOTOL).

The DC-X's hull acts as a lifting body at high speeds, and although such hull designs have traditionally not handled well at subsonic speeds, modern high speed computers should prove fast enough to compensate for the inherent instability of the aircraft for the time it takes the plane to slow from supersonic cruising speed to landing velocity, where the plane's gimballed engines would allow it to land vertically.

The main engines of a DC-X derived spaceplane need only be used, then, during the ascent phase of the flight and during the landing. During the rest of the flight the plane would function as a hypersonic glider. And if that sounds like a far-fetched idea, it should be remembered that during re-entry the space shuttle earns itself the title of "the world's most expensive glider".

It is a matter of common knowledge that several of the systems on the experimental vehicle were taken from existing aircraft (not space vehicles). Much of the technology that is needed, then, is already available. It is today's technology, not tomorrow's dream. Potentially, it would be possible for such a vehicle to fly before the end of the decade (and that's being pessimistic).

Concorde has proved that there is a market for expensive high-speed passenger aircraft, and it is the top end of this market that the DC-X derived vehicle would have to cater for. The DC-X's VTOL capability would prove an asset, for it would negate the need for a long runway.

A DC-X derived plan could, theoretically, land at even the smallest local airport.

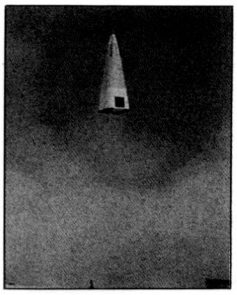
It has been shown that compared with other launch vehicles, the DC-X can be refuelled and ready for lift-off again within a very short time period, which makes a regular passenger service feasible, if initially extremely expensive.

Should such a sub-orbital vehicle be developed, it would find a market, of that there is no doubt, and I suggest that it would make a considerable profit for its developers in the long term. This profit could, potentially, pay off some of the development costs of a launch vehicle large enough to carry worthwhile payloads into space.

I would be interested to read any comments that readers may have regarding the feasibility, or otherwise, of my proposal.

We put these comments to *Paul Blase,* who replies:

Yes, the Delta Clipper may certainly be used in a sub-orbital mode as an Earth-Earth transport. Indeed, Bono and Gatland, in their seminal book on SSTO craft "Frontiers of Space" describe the eco-



DC-X ascends in flight test of 11 September 1993. MCDONNELL DOUGLAS

nomic advantages of a ballistic passenger transport which could go from London to Tokyo in 34 minutes.

G. Harry Stine summarised the situation quite nicely in his article "Comes The Revolution" in the Mid-December 1993 issue of *Analog* magazine when he called sub-orbital hops the "hidden market" for SSTO services. As Mr Stine points out, "Any SSTO spaceship that can take a payload to orbit can also deliver passengers and cargo to any place in the world in less than an hour". Many of the packages that need to get to their destinations that quickly are also the lightest: unpackaged IC dice, legal documents, spare parts for important pieces of machinery and medicines. You can pay 20 dollars per kilo now for next day delivery. I can imagine many businesses that would be willing to pay up to $100 per kilo for same-day delivery. (I have heard that at least one major overnight package carrier is extremely interested in the Clipper already.)

Passengers may be a little longer in coming, but launch costs would only have to drop to around 10 dollars per kilo for a Clipper ticket to be comparable to flying on Concorde (around $3000 per ticket for a 100 kilo person, allowing additional weight equal to twice that of the passenger for a pressurised cabin, life support and a seat). Considering that a lawyer or a high-powered business consultant can charge up to $500 per hour, saving 14 hours on a plane trip could easily pay for the cost of the ticket.

One note on Ms Tromlin's letter: it would not be necessary to configure a special version of the Clipper as a hypersonic airplane, the standard orbital configuration would work best. After all, a sub-orbital (ballistic) hop differs from an orbital flight only in the amount of time spent above the atmosphere. Take-offs and landings would be identical, you simply do not thrust quite so hard on the way up. As an added bonus, a sub-orbital flight could carry up to twice the mass of an orbital one, since the peak velocity to be reached would be considerably less and less fuel would be required (allowing fuel mass to be traded for payload).

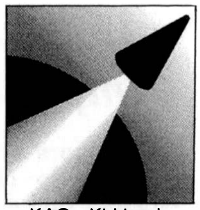
The fact that the Delta Clipper makes extensive use of advanced composite materials to reduce weight was noted by Paul Blase in reply to concerns expressed by Prof. Ruppe of Munich, Germany in ***Spaceflight***, September 1993, p.321. At that time, the latest weight breakdown figures were not available from McDonnell Douglas. *Paul Blase* now writes to update this information:

Recently I was able to view a copy of a McDonnell Douglas report to the National Research Council. This report gives the projected DC-Y empty weight as 104,100 lb and the Gross Liftoff Weight as 1,279,000 lb and states:

> "Advanced fighter aircraft are flying with structural margins of only 1.5... The baseline DC-Y using the [advanced composite] technology [primarily advanced composite materials] and margins indicated above has a 24,800 lb payload capability for a 100 nmi easterly orbit".

This includes a 50% structural design load margin, a 15% structural weight margin, and a performance margin of 12 seconds of Isp (1%). The baseline design relies heavily on graphite epoxy and recently developed aluminium-lithium alloys. Even if these were to be replaced with aluminium alloys and other materials currently used on the Space Shuttle the dry weight would increase by only 14,000 lb - still 1000 lb short of the 15% weight margin. ■

"Opening Up the Space Frontier for Humanity"



KAC, Kirkland, Washington USA.

Kistler Aerospace Corporation (KAC) is planning to design, build, test and operate fleets of reusable, single stage to orbit rocketships that will reduce the cost of access to and from space by a factor of ten, revolutionise the global space transportation industry, and open up the space frontier for humanity.

KAC is a privately financed company with no government funding and no government interference. The company plans to design, build and operate its own fleets of fully reusable rocketships and its own launch, landing, vehicle support and mission operations facilities. KAC has raised its first level of seed financing from private investors and plans to raise up to two billion dollars in development funds during the next five years from private, corporate and institutional sources.

Kistler Rocketships

Kistler Aerospace is in the process of developing a sub-scale fully reusable demonstrator rocket system (the K-0) that will ground and flight test unique, proprietary rocket launcher designs in 1995. These demonstration flights will lead to the design, construction, ground and flight testing, and orbital operations of a fleet of fully reusable K-1 rocketships that will be capable of placing payloads of at least 2,000 lb into low Earth orbit during the late 1990s and beyond. The success of the K-1 rocketships will lead to the development of a fleet of fully reusable, single stage to orbit K-2 spaceships that will be capable of placing 20,000 lb into low Earth orbit just after the turn of the century.

Project Status

The company was founded in November, 1993. The following activities are currently underway:

- Preliminary design of the K-0 rocket system.
- Implementation of plans to begin ground and flight testing the K-0 system at Mojave, California during the 1st and 2nd quarters of 1995.
- Implementation of plans to move ground and flight testing of the K-0 rocket system from Mojave, California to White Sands Missile Range, New Mexico during the 2nd quarter of 1995.
- Conceptual design of the K-1 rocketship system.
- Negotiations with major aerospace companies to undertake the K-1 Phase I design studies which are planned to be completed during the summer of 1994.
- Discussions with NASA centres leading to several SSTO joint technology development activities starting in 1995 and 1996.
- Negotiations leading to the development of a permanent Kistler Spaceport as part of the Southwest Spaceport facility adjacent to White Sands Missile Range, New Mexico, construction of which is planned during the last quarter of 1996.

Future Financing

Approximately $250 million are required for the design, development, ground and flight testing of the K-1 rocketship systems (six orbital vehicles) and the Kistler Spaceport (1995-1998). Approximately $1.0 to $2.0 billion are required for the design, development, ground and flight testing of the K-2 SSTO spaceships (six orbital vehicles), and additional Kistler Spaceport facilities (1996-2002).

The KAC Team

KAC is in the process of assembling a team of highly skilled professional project managers, rocket and space system development engineers and launch and mission operations teams who have worked on all major US space programmes from Saturn and Apollo through Shuttle, Space Station and DC-X.

Track Record

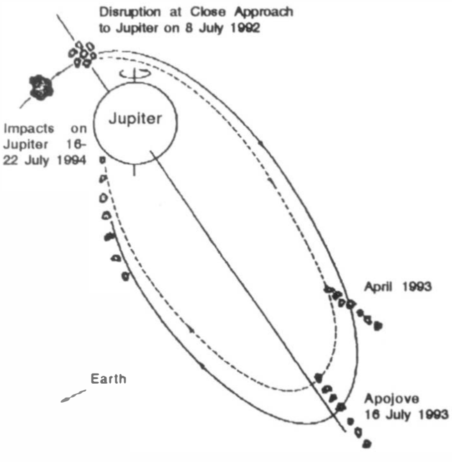
The founders of the company have an excellent track record. Walt Kistler has founded a number of successful companies in the fields of scientific and industrial instrumentation, including Kistler-Morse Corporation of Redmond, Washington. Bob Citron has founded a number of successful companies in the fields of communications and commercial space development, including SPACEHAB, Inc of Arlington, Virginia. ■

Jupiter Comet Impact Update

Astronomers all over the world are preparing to observe the collision between comet Shoemaker-Levy 9 and Jupiter which according to the latest calculations will start in the evening of 16 July and end in the morning of 22 July 1994.

The nucleus of comet Shoemaker-Levy 9 broke into many smaller pieces during a near passage of Jupiter in July 1992. They are now moving in an almost straight line following a highly elliptical orbit around the planet and will all collide with it on their return. More than 20 individual comet pieces have been observed.

Both Jupiter and these nuclei have been extensively observed during the past months. A large, coordinated observing programme by the European Southern Observatory at La Silla has been active since early April and the first results have become available. However, while we now possess more accurate information about the comet's motion and the times of impact, there is still great uncertainty about the effects which may actually be observed at the time of the impacts.



The fragments of Shoemaker-Levy 9 move around Jupiter. (This schematic could not be drawn to scale. For example, the distance to apojove is actually almost 1,200 times the disruption distance, and the true representation would be a long narrow ellipse, e > 0.99, that looks almost like a straight line out and back. The length of the line would be 350 times the diameter of Jupiter and the disruption a tiny dot at less than a quarter of the diameter of Jupiter from it.) Prepared by Z. SEKANINA, P.W. CHODAS and D.K. YEOMANS

The first object will hit the Jovian atmosphere somewhat later than earlier predicted; the best estimate is now at about 22:00 CEST* in the evening of Saturday, 16 July 1994. The second will follow the next morning at about 5:00. These two nuclei are comparatively faint and it is uncertain whether these impacts will actually be observed.

The first, relatively large nucleus will hit Jupiter around 17:00 on 17 July. The brightest nucleus is expected to arrive just before 22:00 on 20 July, and the last in the train should collide with the planet at about 10:20 on 22 July. The timing uncertainty varies from impact to impact; in the best cases, there is at present a 95% chance that the collision will happen between 40 minutes before and 40 minutes after the indicated time.

Despite intensive spectroscopic observations, no gas has yet been detected in any of the nuclei. The amount of the dust has been steadily decreasing; this is because the dust production from the individual nuclei - which began when the parent body broke up at the time of the near-collision with Jupiter in July 1992 - is slowly diminishing with time.

Some of the smaller nuclei have recently disappeared from view, probably because they have ceased to produce dust. It is not clear, however, whether this also implies that they no longer exist at all, or whether they are just too small to be seen with available telescopes.

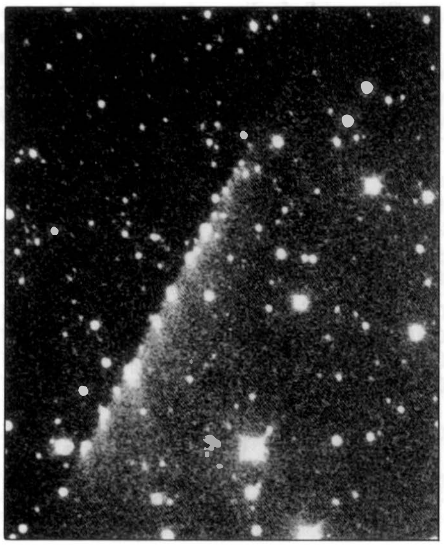
The comet fragments will impact at an angle of about 42° from vertical near a latitude of 44° S and a longitude 70° past the midnight meridian, still 10° beyond the limb of Jupiter as seen from Earth.

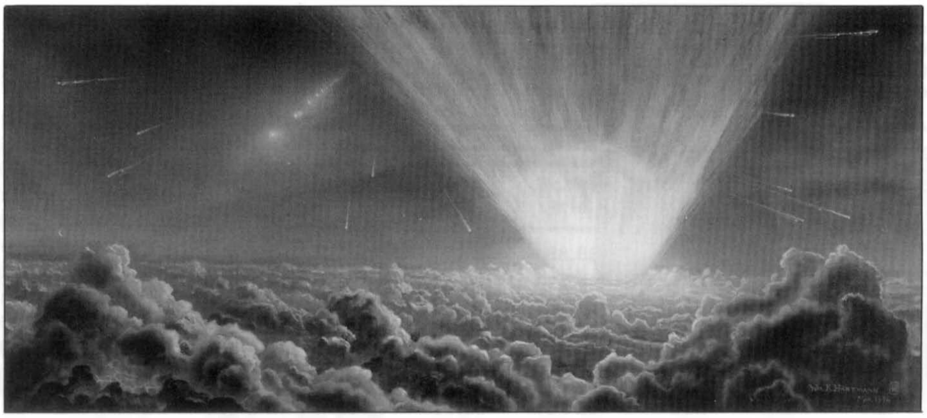
Observing conditions from Earth will not be ideal at the time of the impacts, since there will be only about two hours of good observing time for large telescopes at any given site after the sky gets dark and before Jupiter comes too close to the horizon to observe. With 21 pieces hitting over a 5.5-day period, there will be an impact on average about every 6 hours, so any given site should have about one chance in three of observing at the actual time of an impact each night. Since the impacts will be on the back side of Jupiter, light from the impacts can only be observed by reflection from Jupiter's moons or perhaps from the rings or the dust comae of the comet fragments.

Those attempting observations of the effects of the impacts on Jupiter can begin about 20 minutes after the impacts, when the impact area rotates into view from Earth.

* Times are given in Central European Summer Time (CEST), i.e., Universal Time (UT) + 2 hours.

This photo was obtained on 1 May 1994 with the ESO 1-metre telescope using a 5 min exposure in red light. The entire nuclear train (the "string of pearls") is very clearly seen, together with the sunlight-reflecting dust from the nuclei, all on one side. The extension of the train was just over 1 million km. ESO





Impact in the Clouds

This wide-angle view shows the impact of Comet Shoemaker-Levy 9 as seen from a point just above Jupiter's cloud deck, looking south. The string of comet fragments is approaching from the southern sky, and stretches back along the orbit of the comet.

One fragment has just penetrated the clouds. This view, based on some computer simulations of the impact, shows the scene some tens of seconds after the explosion as the brilliant fireball explodes upward through the clouds. The sky is ablaze with meteors, which are much tinier particles dislodged from the comet and mingled with the kilometer-scale fragments of the nucleus.

On the horizon, above the sunset glow, is Jupiter's satellite, Io, appearing about the size that our moon does from Earth. Its night side is illuminated by the flash from the impact.

PAINTING BY WILLIAM K. HARTMANN

Ice on Mercury

New radar maps of Mercury obtained with the Arecibo radio telescope seem to confirm the presence of permanent ice at its poles. John Harmon who with colleagues reports the findings in the 19 May issue of *Nature*, said the ice deposits appear to be at least several metres thick and to sit in deep craters in Mercury's polar regions. As the planet's spin axis is perpendicular to its solar orbit, the poles never dip toward the Sun and Mercury's ultra thin atmosphere cannot hold enough heat to melt it.

At the Edge of the Solar System

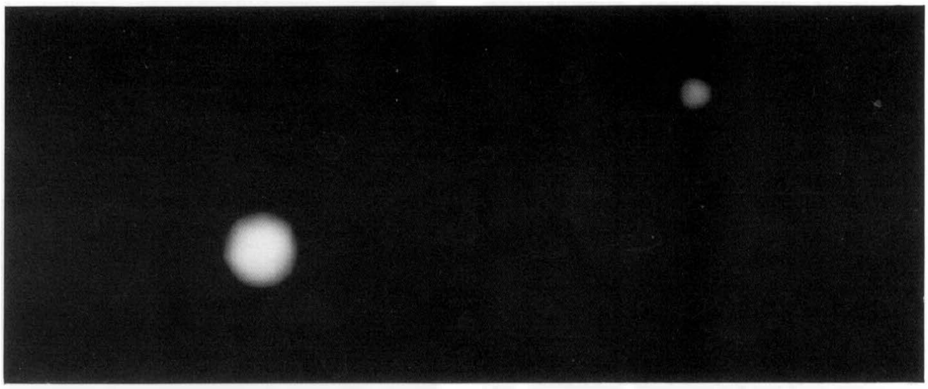
Hubble Space Telescope Turns to Pluto/Charon

This photo *(right)* is the clearest view yet of the distant planet Pluto and its moon, Charon and was taken when the planet was 4.4 billion km from Earth, or nearly 30 times the separation between the Earth and the Sun.

Hubble's corrected optics show the two objects as clearly separate and as sharp disks. This now allows astronomers to measure directly (to within about 1%) Pluto's diameter of 2320 km and Charon's diameter of 1270 km.

The Hubble observations show that Charon is bluer than Pluto. This means that both worlds have different surface composition and structure. A bright highlight on Pluto suggests it has a smoothly reflecting surface layer. A detailed analysis of the Hubble image also suggests there is a bright area parallel to the equator on Pluto. This result is consistent with surface brightness models based on earlier photometric observations from the ground. However, subsequent HST observations will be required to confirm whether the feature is real.

Though Pluto was discovered in 1930. Charon was not detected until 1978. That is because the moon is so close to Pluto that the two bodies are typically blurred together when viewed through ground-based telescopes. The new HST image was taken when Charon was near its maximum elongation from Pluto of 0.9 arc seconds. The two bodies are 19,640 km apart. Hubble's ability to distinguish Pluto's disk at a distance of 4.4 billion km is equivalent to seeing a baseball at a distance of 64 km.



Pluto and Charon taken by the ESA Faint Object Camera of the HST on 21 February 1994.
DR R. ALBRECHT, ESA/ESO SPACE TELESCOPE EUROPEAN COORDINATING FACILITY: NASA

Research Details

A Very Special Pair of Celestial Objects

Almost all the known facts about these two bodies show that they are quite unusual: Pluto's orbit around the Sun is much more elongated and more inclined to the main plane of the Solar System than that of any other major planet; Charon's orbit around Pluto is nearly perpendicular to this plane; their mutual distance is amazingly small when compared to their size; Charon is half the size of Pluto and the ratio of their masses is much closer to unity than is the case for all other planets and their moons. Moreover, both are small and solid bodies, in contrast to the other, large and gaseous planets in the outer Solar System.

We do not know why this is so. But there is another important aspect which makes Pluto and Charon even more interesting: at this very large distance from the Sun, any evolutionary changes happen very slowly. It is therefore likely that Pluto and Charon hold important clues to the conditions that prevailed in the early Solar System and thus to the origin and the evolution of the Solar System as a whole.

Long and Difficult Analysis Ahead

The image above shows that the overall quality of the new data obtained with the ESA Faint Object Camera on the refurbished HST is extremely good. However, such an image represents only the first step of a subsequent, detailed analysis which will be very demanding and involve experts in many different fields. While still in its preliminary stages, it already appears to indicate areas of different reflectivity on the surface of Pluto. By a comparison of HST images obtained at two different wavelengths (i.e. in ultraviolet and visual light), the team members hope that it will become possible to construct rough maps of the planetary surface and perhaps also to answer the long-standing question of whether or not there is an atmosphere around Pluto. ESO

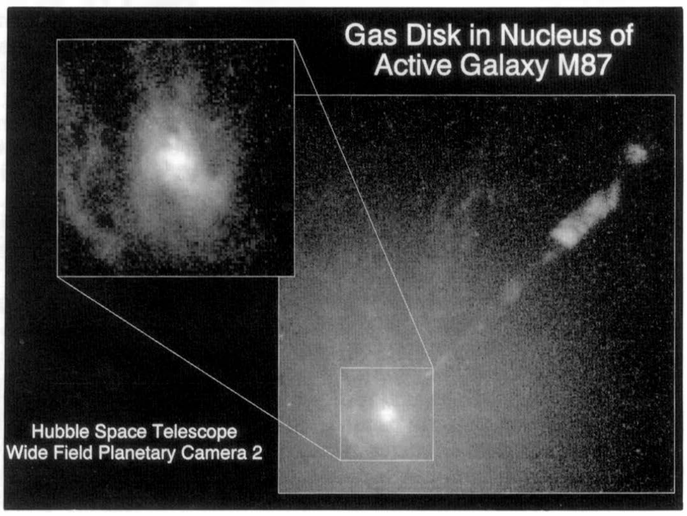
Hubble Finds Black Hole

For decades, black holes were not regarded as real astronomical objects, but merely as mathematical expressions of objects that are so massive yet compact that nothing can escape their gravitational attraction, not even light. With the discovery of active galaxies and quasars, black holes became the favoured explanation for energetic events.

Earlier Hubble Space Telescope observations found strong circumstantial evidence for the presence of a massive black hole in the core of M87. However, the black hole's mass could not be determined until Hubble's spectroscopic capabilities were improved by the installation of COSTAR during the Servicing Mission in December 1993.

The observations led to velocity measurements of the gas that is rotating in the form of a disk around the black hole and hence to the mass of the object at the centre of M87. It weights as much as three billion suns, but is concentrated into a space no larger than our Solar System and so fits the requirements of a black hole.

HST measurements show the disk is rotating so rapidly that it contains a massive black hole at its hub. The diagonal line across the image is a jet of high-speed electrons believed to be produced by the black hole "engine". STScI/JHU/NASA

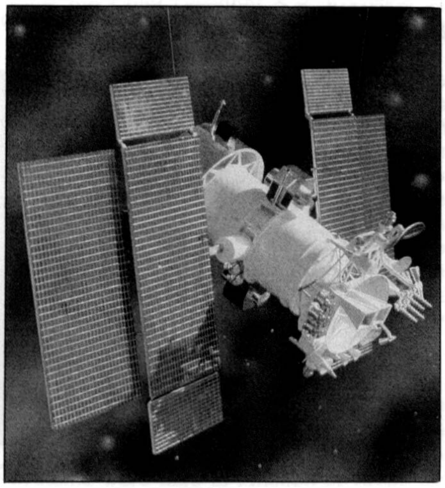


Commercial Launch for Russia

On 20 May, Russia launched one of its Gorizont communications satellites by a Proton rocket into geostationary orbit from Baikonur for the US company Rimsat, thereby marking a major advance in Moscow's efforts to enter the world space market.

The first launch of a Gorizont satellite for Rimsat was in November 1993 and was the first time Russia had ever put up a satellite for totally commercial purposes for a Western company. Rimsat was attracted to Russian spacecraft by their reliability and relative cheapness.

Rimsat is the major foreign partner of Informcosmos, an association of leading Russian space enterprises which is responsible for commercialising Russia's space technology and developing its satellite communications. Rimsat made a $140 million deal with Informcosmos in 1992, providing for the lease, launch and operation of three Gorizont and four newer Express satellites, with options on 10 additional spacecraft. Gorizont is the workhorse of Russia's worldwide satellite telephone and television systems, but will gradually be replaced from this year by the larger and more versatile Express, which has a longer warranted life span and multiple beam antennas.



Gorizont communications satellite.

Gorizont is built by NPOPM, the world's largest satellite producer. The seven-transponder Gorizont launched on 20 May went into orbit over Malaysia with AllAsia Sat of Manila as its first customer. Licenses for Rimsats' satellite positions have been obtained from TongaSat, the communications authority of the Kingdom of Tonga, and Tonga's Crown Prince Tupoutoa attended the launch.

Satellite Network Signs Up for Launch

McDonnell Douglas announced on 14 April that it had signed a contract valued in excess of $400 million with Motorola to launch the majority of the satellites needed to form the global Iridium Telecommunications network.

The $3.37 billion Iridium system will provide global wireless hand-held telecommunications services including voice, facsimile, data, and paging via 66 lightweight satellites in low-Earth orbit. (See ***Spaceflight***, February 1992, p.46).

The satellites will be placed in six orbital planes consisting of eleven satellites each, positioned approximately 420 nautical miles above the Earth. The satellites will be interconnected through cross-links to provide complete coverage of the Earth's surface. Plans call for the first launch to take place in 1996 with commercial service anticipated in 1998.

The contract is the largest commercial contract McDonnell Douglas has received as a provider of satellite launch services. The agreement calls for the launch of eight Delta II launch vehicles to place 40 communications satellites in low-Earth orbit.

Launch services for the remaining complement of satellites will be provided by the Khrunichev State Research and Production Space Center and China Great Wall Industries.

The Iridium system will allow subscribers to use pocket-sized hand-held wireless telephones to communicate with virtually any other telephone in the world. Communications will be relayed via satellite and through ground-based gateways, placed in key regions worldwide, that will interconnect with public telephone networks. In areas where conventional terrestrial cellular service is available and compatible with Iridium dual-mode telephones, the subscribers' communications will transmit over the cellular network.

Another satellite network is planned by Loral Corporation with a 48-satellite mobile telephone system called Globalstar and plans were recently announced for a $9 billion satellite system by Teledesic Corporation (***Spaceflight***, May 1994, p.157).

China Launch Go Ahead

Despite the explosion in April at China's space launch centre (***Spaceflight***, June 1994. p.185), plans to launch three satellites for foreign clients this year are on schedule. China is seeking to expand its slice of the international space launch market and offers its Long March rockets as a cheaper alternative to launch services provided by US or European agencies. It plans to launch a total of 30 satellites for foreign clients by the year 2000.

Russian Launch Failure

On 26 May the launch of the Russian military Cosmos 2281 satellite by a Cyclon-3 booster from Plesetsk failed and the payload plummeted into the Arctic Ocean. The failure is thought to have occurred in the second stage but the exact cause is unlikely to be discovered.

STS-64 Crew

US Navy Commander Jerry M. Linenger, 39, has been added to the crew of STS-64 as a mission specialist and is making his first flight, which is scheduled for September 1994 aboard Discovery. He joins USN Captain Richard N. "Dick" Richards, Commander; USAF Colonel L. Blaine Hammond, Pilot; and mission specialists USAF Colonel Carl J. Meade, USAF Lt. Col. Mark C. Lee and USAF Lt. Col. Susan J. Helms who were all named as crew in November 1993.

The assignment was made to more efficiently distribute the crew workload for the complex flight, which in addition to payload operations, includes a rendezvous and a spacewalk. The STS-64 mission will carry the LIDAR In-space Technology Experiment (LITE), the Robot Operated Materials Processing System (ROMPS) and the Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN-201). LITE will measure atmospheric parameters from a space platform utilising laser sensors. ROMPS will investigate robot handling of thin film samples. SPARTAN is a free-flying retrievable x-ray astronomy platform.

Astronaut for OSC

In June 1993, Ronald J. Grabe was on his fourth space shuttle mission (STS-57) commanding the first flight of the commercially sponsored Spacehab module, when he decided at 48 years of age that it was time for him to set his sights on a new job. One of his crew members, Janice Voss Ford, had been an Orbital Sciences Corporation (OSC) employee prior to coming to NASA and she suggested that he gave OSC a call.

Now after 14 years with NASA he has joined OSC as vice president of business development for OSC's launch systems group. One of his priorities, he says, will be to find new markets for the Taurus and Pegasus space rockets. "We think there is great potential in the low-Earth orbit market," he said. The company is about to enter the communications marketplace through its ORBCOMM satellite system, the first launch being scheduled for this summer. The satellite network is designed to provide two-way paging and messaging services worldwide "at consumer-level prices" and will be the first in the world to provide global communications using small satellites in low-Earth orbit.

Pegasus Launch

An Air Force Space Test Experiment Platform Mission 2 satellite, intended to test military radio communications, was launched on 20 May by a Pegasus four-stage launch vehicle carried aloft by a B-52 bomber.

The satellite, which has four fixed solar arrays and weighs just 398 pounds, was supposed to go into a 517.5-mile polar orbit, but instead it ended up in an orbit ranging between 379.5 miles and 523.25 miles high. The satellite is in good condition and may be able to complete it mission.

STS-59

Endeavour Looks for Clear Skies

Brings Back a Wealth of Earth Surface Data

Endeavour and its crew of six landed safely at Edwards Air Force Base on 20 April at 11:54 am CDT bringing to a close the Space Radar Laboratory-1 mission after 11 days, 5 hours and 49 minutes in orbit. This mission had been the first to be undertaken by Endeavour following its highly successful Hubble repair mission.

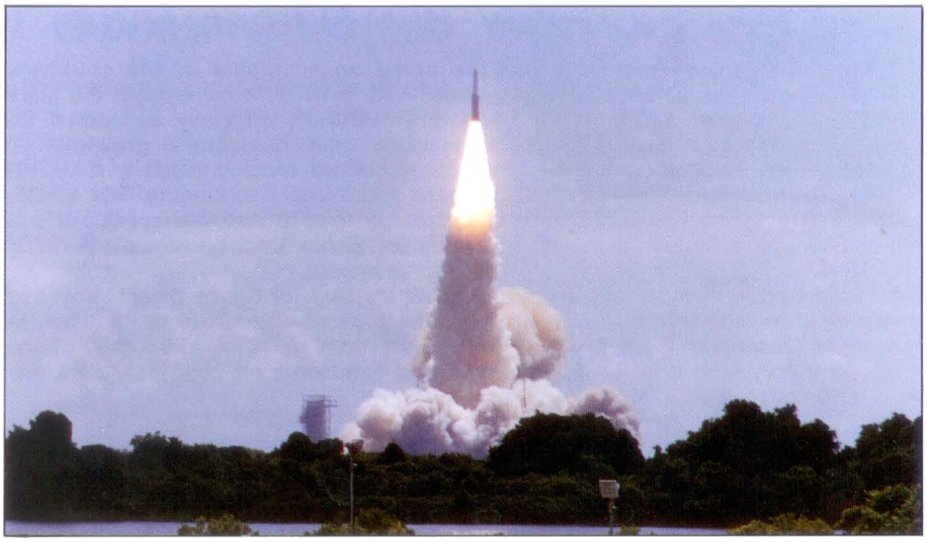
Clouds and rain showers were forecast for both scheduled landing opportunities at the Kennedy Space Center on 19 April at 11:52 am EDT and one orbit later at 1:23 pm. Following a nearly continuous review of weather conditions by flight controllers at the Johnson Space Center and Shuttle Training Aircraft flights by Chief Astronaut Robert "Hoot" Gibson, the decision was taken at 12:30 pm to postpone the landing until the following day when four landing opportunities would be available - two at KSC and two at Edwards serving as a backup.

Early weather forecasts on the 20th April were for similar conditions again at KSC whereas good weather was expected for both landing opportunities at Edwards. The flight controllers' philosophy was to try to land at KSC on the first opportunity and, if that was not possible, to take either KSC or Edwards on the second opportunity.

The crew returned having gathered radar data from about 12 per cent of the Earth's surface including 25 per cent of the land area and 400 selected regions. To augment the radar data, the astronauts took some 14,000 photographs. Also, ground-based surveys were carried out by about 2,000 scientists, teachers and students. The full complement of payloads will fly again on Endeavour for mission STS-68 in August.

A detailed report of the STS-59 mission is due to appear in the next issue of ***Spaceflight***.

On board Endeavour, Astronaut Linda M. Godwin uses the Shuttle Amateur Radio Experiment (SAREX). Several crew members spent off-duty time using the radio equipment to communicate with Hams and students on the ground. The crew also used the equipment to speak with NASA Kenneth D. Cameron in Moscow, as well as astronaut Bonnie J. Dunbar, NASA flight surgeon Dave Ward and two cosmonauts, also in Russia. Astronaut Jay Apt contacted the current crew of the Mir space station. A total of 1694 amateur radio operators from 46 countries contacted Endeavour during the mission. NASA



Lift-off of a Titan 4/Centaur from Pad LC-41 at 11:55 am EDT on 3 May at Cape Canaveral Air Station. PETER GUALTIERI, WEST KENTUCKY NEWS

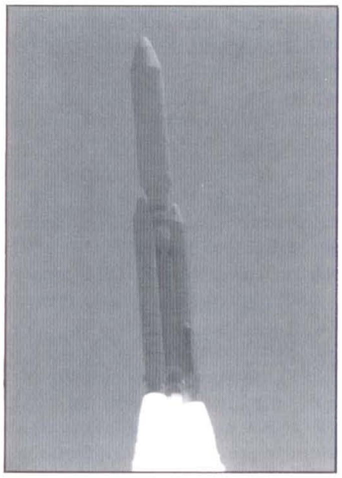
Classified Launch Keeps Cameras Away

When a Titan 4 was launched with a classified Department of Defence payload at 11:55 am EDT on 3 May from the Cape Canaveral Air Station*, the Air Force did not allow remote cameras at the launch site.

Cameras at the viewing area were able to cover the launch scene over a wide angle as shown by the above photo and the launch was indeed a spectacular sight as the vehicle rose upwards on a vertical pillar of exhaust and flame into a still atmosphere.

Distance from the launch pad can, to a certain extent, be made good by more powerful optics as shown by the photo on the right, but there was little contrast between the vehicle and the background sky. Viewing was to the East with a noonday sun high in the southern sky so that the facing side on the vehicle was not strongly illuminated. The vehicle soon went behind low cloud and could not therefore be viewed unimpeded from the effects of the lower atmosphere heated to 85 degree F by an intense Florida sun.

* Until recently, named the Cape Canaveral Air Force Station.



A shot during the boost phase of the flight from a distance of 3 miles with a Celestron 8 inch telescope, 2000mm focal length f/10. PETER GUALTIERI, WEST KENTUCKY NEWS

Mars Probe Delay Hits Experimenters

Russian funding problems have put the brake on a number of the country's unmanned space activities (*Spaceflight*, June 1994, p.184). These include the Mars programme with two missions, MARS-94 and MARS-96, originally scheduled for launch later this year and in 1996 with payloads from international groups.

In March, the Russian space and technology council recommended that MARS-96 be delayed as MARS-94 had used up most of the available funding. The MARS-94 schedule is at present being maintained except for the all-important commitment to a launch date which has fallen victim to the uncertain funding situation.

Affected by the delay is the University of Kent's Unit for Space Sciences whose involvement in MARS-94 was described by the project's leader, Howard Shaw, in *Spaceflight*, December 1992, p.379. We now hear from Dr Mark J. Burchell of the same laboratory who updates the situation and comments on how their work has been affected.

Situation Analysed

Since the mid 1970s the USSR saw the paramount importance of Mars as a target for exploration and had a planned and coordinated programme of missions to this end. Originally the Phobos missions were to lead, followed by MARS-94, MARS-96 and MARS/ASTER, resulting in the establishment of a seismic and meteorological network on the planet, a number of Martian sample return missions, and finally to a manned landing well into the 21st century. Even the loss of the Phobos mission did not deflect the Russian space agencies from this coordinated plan.

Despite the USSR/Russia political changes this programme appeared to remain a major goal. This allowed the MARS-94 mission to continue without modification up to the end of 1993. Since then rumours of delays have widely circulated. It is now accepted that the mission will be launched in 1996, with a payload mostly similar to that planned for the original mission.

From the inception of MARS-94 in 1989, the proposed launch date of October 1994 was always seen as difficult to meet. Any technical or funding difficulties encountered during the design or construction phases of the mission were always going to put considerable pressure on the schedule. The Russian design teams have applied considerable pressure to the international collaborators to ensure that any instruments and sub-systems designed and constructed outside Russia (initially there were 23 separate countries collaborating in MARS-94) were delivered on time.

Although delays may have occurred in other parts of the mission the work at the University of Kent has continued on schedule. We have been involved in design and construction of electronics to control experiments in the lower body of each of the two dart/missile shaped penetrators designed to impact and bury themselves in the Martian surface. The penetrators fall from orbit and are slowed by their descent through the atmosphere. At impact they are still travelling at 100 m/s. The design of the electronic units had to meet the criteria that they would survive impact, operate at very low power levels, survive the shock of takeoff, survive the flight, and operate at temperatures to be expected on Mars. The units operate several instruments*, distributing power and commands, and gathering data for packaging and transfer to the transmitter which returns the data to the main body of the craft which stays in orbit.

The two fully operational flight ready electronic units (and supporting casings) were shipped to Moscow on schedule during April. The original schedule, which is still being maintained, called for them to be integrated with power circuits and the flight quality instruments at end of May/early June. Staff at University of Kent are awaiting confirmation that these tests have commenced.

In the near future here at the University of Kent we plan to operate simulations of the various instruments connected to a model of the electronics. Such simulators will be used to gain experience as regards analysis of data expected from the mission. We retain our rights to share data from the mission (when it is launched), so wish to be prepared to analyse any data that is eventually obtained.

View from the University of Kent

The delay of two years is very disappointing. Some of the staff here have worked for up to three years on this project, particularly Mr Howard Shaw who did most of the design and construction. The flight time to Mars was to be approximately 11 months, so some delay between delivery of equipment and getting data was always anticipated. But to suddenly be faced with an extra delay of two years is very depressing. Myself, I was very keen to start considering Martian science and had begun some tentative analysis exercises anticipating data. These will now slow down and I will have to focus my attention elsewhere for two extra years. On a mundane note I will have to explain to various administrative committees why I will not be publishing papers as expected over the next few years. This may sound dull but careers are built on what you do, not on good explanations of delays!

Staff in general will now join others working on other projects unrelated to MARS-94. Such work inside the Unit for Space Sciences involves studies of hypervelocity impacts, development of instruments to detect such impacts on spacecraft, development and design work for the Rosetta mission and a major activity on the Cassini/Huygens mission due for launch in 1997.

DR MARK J. BURCHELL

**The instruments are designed to carry out chemical analysis of the Martian subsurface, and also include seismometers to study Mars quakes. The latter is one of the major goals of Martian science as the most reliable way of probing the structure of Mars' interior.*

SSTL Technical Director, Professor Martin Sweeting (left), and Air Attaché and Head of the Chilean Air Force Mission in London, Group Captain Patricio Rios, sign the FASat-Alfa contract in the University of Surrey's new Centre for Satellite Engineering Research. SSTL

Chilean Satellite

On 13 May, Britain's premier small satellite company, Surrey Satellite Technology Limited (SSTL) announced the signing of a £3 million microsatellite contract with Chile.

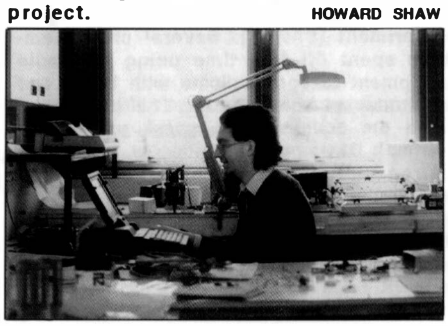
The technology-transfer programme, which has been initiated by the Chilean Air Force commences immediately and will focus on the construction of the first Chilean satellite (FASat-Alfa), installation of a control ground station in Chile and on-the-job training for eight Chilean Air Force engineers. FASat-Alfa will be built and tested at Surrey by a team of Chilean engineers working alongside experienced SSTL staff.

Malaysian Satellite

On 17 May, Hughes Aircraft Company signed a multi million-dollar agreement with Binariang Sdn Bhd of Kuala Lumpur for construction of the Malaysia East Asia Satellite (MEASAT) system, which is designed to offer both direct-to-user (DTU) service in Malaysia and general communications services in the region from Malaysia to the Philippines and from Beijing to Indonesia. DTU services include television programming delivered to small, 20-inch-diameter home antennae.

The satellite is to be launched late in 1995 and an option exists for a second essentially identical satellite. Both satellites are to provide 12 years' service.

Howard Shaw at work in the laboratory constructing electronics for the MARS-94 project. HOWARD SHAW



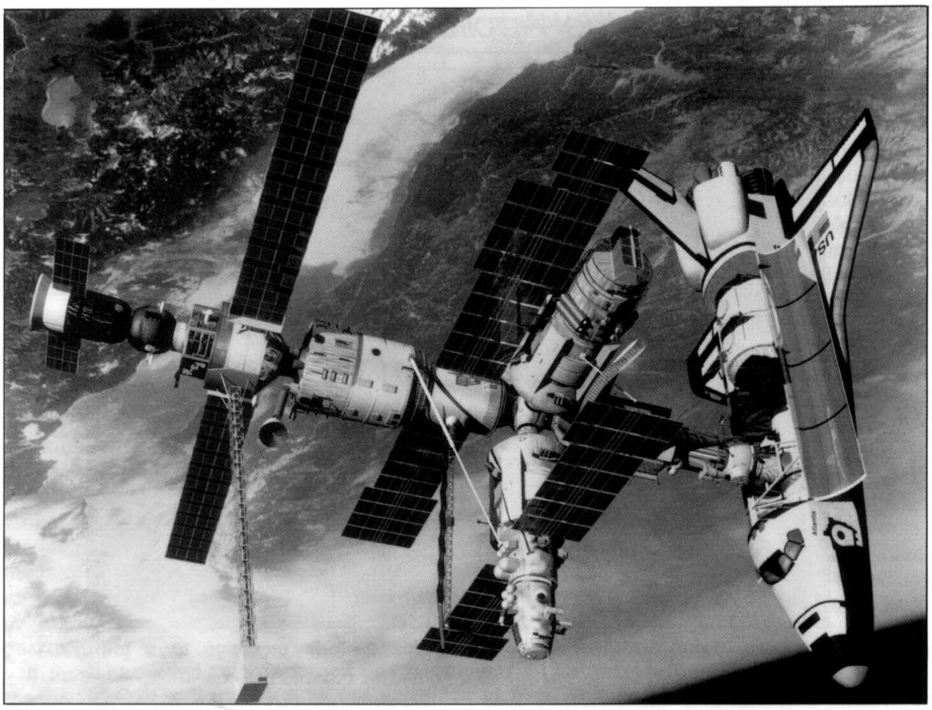
Atlantis-Mir Docking

Right: **A technical rendition of the Space Shuttle Atlantis docked to the Kristall module of the Russian Mir Space Station. The configuration shown is that of the STS-71/Mir Expedition 18, a joint US-Russian mission scheduled for June 1995.**

Atlantis appears in a new configuration for the STS-71 flight. The Russian developed Adrogynous Peripheral Docking System (APDS) is used to link the Orbiter to the Kristall module. The APDS is mounted atop a US developed external airlock which connects to a modified tunnel section leading to the Spacelab module in the far aft of the payload bay.

Mir is shown in its six module configuration. The Kristall module has rotated to the forward docking port of the Mir Base Block to facilitate the docking of the Space Shuttle. The Priroda module is shown extending over the port wing of the Orbiter with its solar panel in the retracted position required by the dynamics of Orbiter/Mir docking.

The Kvant 2 airlock module appears parallel to the Orbiter crew module, while the Spektr module is at the nadir and is hidden from view by the port solar panel of the Mir Base Block. The Kvant module is shown at the aft of the Mir Base Block with solar panels of the Kristall module installed and fully extended. The Soyuz TM transport vehicle used for the launch and docking of the Mir Expedition 18 crew is docked to Kvant. **NASA**



Solar Array Modules

Modules of interconnected solar cells are on their way from the US to Russia where NPO-Energia will validate design and assembly procedures prior to the arrival of the flight units in September and their subsequent launch to Mir on the Space Shuttle in October 1995.

The advanced array, known as the Cooperative Solar Array, combines Russian flight-proven structures and mechanisms with American advanced solar array modules to increase the available user electrical power on the station. The Cooperative Solar Array project timeline will be less than two years from inception to deployment of the jointly produced array, making it one of the first pieces of hardware to be launched in the International Space Station programme.

Canada Cuts Station Budget

On 3 June Canada announced that its contribution to the International Space Station is to be reduced by 40 per cent. It will still remain a full partner of the project at a cost of US$362 million over 10 years.

Joint Moon Programme

The world's main space agencies met in Switzerland at the beginning of June to discuss an ESA proposal for a joint international Moon programme.

The programme would begin with relatively modest lunar orbit satellite missions and could culminate in setting up human outposts on the Moon, but the go-ahead will depend on approval from ESA member states.

Space Station in the Balance

Shuttle Flight Cuts Proposed

A new, smaller 1995 space programme is proposed by George Brown, California, Chairman of the House Science, Space and Technology Committee, who supports building the space station but proposes a budget cut that would take out one of next year's eight shuttle flights and perhaps two in future years.

Although George Brown has been a champion of the space station and steered its passage through an often hostile Congress, where last year it came within one vote of being defeated, he said that if Congress were to reduce the amount still further, he would no longer give the space station his backing. Its chance of surviving this time, he rates as 50-50.

Since last year's single vote approval, NASA argues that it has redesigned the station, selected a new prime contractor, signed a partnership with Russia and restructured the project's internal chain of command. NASA Administrator Dan Goldin stands firm on the Agency's $2.1 billion request for the space station in 1995 and has not been forthcoming with an answer for accommodating a $200 million cut. NASA estimates that to complete the project $17.4 billion will be needed, in addition to the $11 billion already spent, and has pledged not to exceed that amount.

Orbiter Refurbished

Modifications to the Atlantis orbiter that have been underway at Rockwell's manufacturing facility in California for the past 19 months have been completed two weeks ahead of schedule. The orbiter has returned to KSC to be prepared for its late-October launch on mission STS-66.

The 800 modifications included provisions to enable Atlantis to fly longer missions and to prepare it to dock with the Russian space station Mir for a series of Shuttle/Mir missions starting next summer to serve as a precursor to the construction of the International Space Station. An orbiter docking system is currently under construction at Rockwell and the electrical wiring for it was installed.

Engineers and technicians entered the orbiter's wings and other structural areas to perform nearly 400 visual and non-destructive test inspections, searching for fatigue, corrosion, stress cracks and broken rivets or welds. Results confirmed Atlantis to be in an overall excellent condition.

Next orbiter to go to Rockwell this autumn will be Columbia for modifications that will take seven months and include structural inspections and 60-70 upgrades, including the first phase of the Multifunctional Electronic Display System (MEDS), or "glass cockpit". Discovery is then scheduled to go to Rockwell in September 1995 for similar work, plus installation of a fifth cryogenic tank set. Mir modifications similar to those performed on Atlantis and upgrades to allow docking with the International Space Station will also be undertaken.

Space Policy of the Apollo Era

President John F. Kennedy delivering his historic message to a joint session of the Congress on 25 May 1961 when he declared, "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth". In the background on the left is Vice President L.B. Johnson. NASA

Kennedy, Apollo and the Columbus Factor

The flights of Apollo collectively stand as a watershed in all of man's history, irrespective of any disenchantment with the United States space program following the successful lunar landings. Ever since the moment Neil Armstrong took his "one small step for man, one giant leap for mankind", anyone looking up at the Moon knows explicitly that human beings have walked on its surface and have looked back on the Earth, floating through the blackness of space. Motion pictures, television and still photographs have attempted to capture such images and writers have sought words to convey the awe and significance of the event.

BY LAWRENCE SUID
Washington, DC

As time passes, more and more people see Apollo as a Cold War stunt rather than one of the two or three most significant events in the history of man. In large measure, this perception has resulted from scholarly efforts to explain President John Kennedy's decision to commit the United States "to achieving the goal, before this decade is out, of landing a man on the Moon, and returning him safely to the Earth". Beginning with John M. Logsdon's 1970 groundbreaking book *Decision to go to the Moon*, the focus has remained on the political aspects of Kennedy's response to the challenge which the Soviet Union's launching of Sputnik presented to the free world.

In his 1984 Pulitzer Prize winning book *... the Heavens and the Earth*, Walter McDougall argues that the United States found itself bound to respond to all that Sputnik represented in order to maintain its "superiority in the technology of mass destruction" so that it could continue to shield "those under its umbrella from external aggression". McDougall believes that Sputnik and the subsequent Soviet space spectaculars, which culminated with the orbiting of Yuri Gagarin in April 1961, "seemed to show that communism was the best path toward rapid modernisation" [1].

According to McDougall's interpretation, President Kennedy embarked on the Moon landing programme in order to reestablish the nation's pride as well as prestige throughout the world. He does admit:

> 'We will probably never know precisely what was in Kennedy's mind when he decided that Americans should go to the Moon. What may have tipped the balance for him and for many was the spinal chill attending the thought of leaving the Moon to the Soviets. Perhaps Apollo could not be justified, but, by God, we could not not do it".

Coming so soon after the Bay of Pigs fiasco, Kennedy's decision also seemed to be a way by which the President might divert attention for the humiliation of the Cuban debacle [1].

Within days, as Michael Beschloss explains [2], two events, Yuri Gagarin's orbital flight on April 12, and the failure of the Bay of Pigs invasion forced Kennedy to change his plans. According to Beschloss, "Kennedy could easily afford to tolerate the Gagarin success. Less than three months in office, he knew that he could not be blamed for the American disadvantage he had criticised so sharply on the campaign trail". The Bay of Pigs fiasco remained another matter.

In fact, President Kennedy did not begin the decision-making process on 20 April after he had concluded that the Bay of Pigs had failed. He made the decision that the United States should go to the Moon before the invasion of Cuba began on 17 April 1961. Everything that followed, including Kennedy's request to the Vice President to "come up with something fast in space", resulted from the President's efforts to find support for his decision.

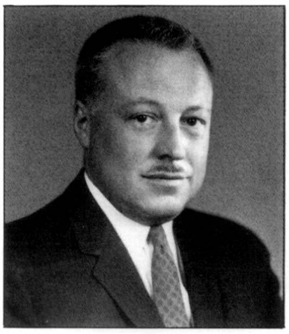
To give Beschloss and other scholars their due, they rightly place President Kennedy's decision to commit the United States to landing a man on the Moon in the context of the Cold War. The successes of Sputnik and Yuri Gagarin raised doubts among people throughout the world about the ability of the United States to match the Soviet advances in space. In the first months of his administration, the President did face the task of finding a viable response to the Soviet space programme that would gain him support within the country and respect for the United States abroad.

Without question, the Soviet orbital success did force President Kennedy to address the lack of direction in the American space programme and probably sooner than he might have otherwise. However, the evidence shows that Kennedy and his advisors had information that the Gagarin flight was probably going to take place on 12 April. Kennedy's press secretary Pierre Salinger had even prepared a congratulatory message and the President had told his aides not to wake him when the Soviets released the story. This does not sound like the actions of a President who panicked in the face of Gagarin's successful flight and soon undertook an unreasonable course of action [3].

Kennedy had been wrestling with the problem of how to respond to the Soviet successes in space since taking office. For a variety of reasons, he had not taken any significant actions up to 12 April. Gagarin's flight did finally focus the President's attention on the faltering American space programme and led to his decision to commit the nation to a moonlanding programme. Nevertheless, if Gagarin's success did lead directly to a definitive decision, the Bay of Pigs fiasco very clearly did not have the slightest influence on Kennedy's calculations.

* * *

Printed sources and historical records in the NASA History Office provide a clear explanation for the proc-



Eugene M. Emme, NASA historian and BIS Fellow.

ess and a specific time and place in which President Kennedy made his decision. In his writings [3-6], Sidey describes a meeting in the White House Cabinet Room at which President Kennedy sought information from advisors on how to address the Soviet challenge in space. At the end of the meeting, the President and Ted Sorensen, his special counsel, retreated to the Oval Office. Five minutes later, Sorensen emerged and informed Sidey: "We are going to the Moon" [3, see pp.118-20; 5 see, pp.15-16;7].

The date of that meeting was 14 April 1961, three days before the Bay of Pigs operation began. Does Sidey's account have credibility? Any historian must ask that question. To answer it, I talked with Sidey, others who attended the meeting including James Webb, David Bell and, most importantly, Sorensen himself. Each man vouched for the accuracy of Sidey's accounts. In particular, Sorensen also answered the key question: what happened during those five minutes? He said that he and the President simply reviewed the inputs received earlier in the day and at the meeting, and then decided that going to the Moon was the only option [7-10].

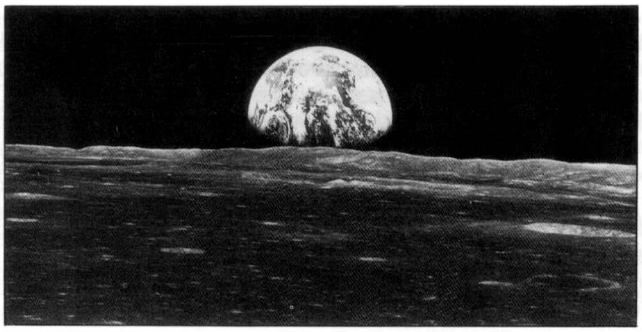
What were the reasons for that decision? Sorensen provided four in relative order of importance [10]:

1. The need to achieve and demonstrate technological superiority over the Soviets;
2. Gains for science and technology, potential gains for US industry and society, etc. (regardless of competition with the Soviet Union);
3. The New Frontier and adventure, the reaching out to new worlds;
4. The "focus argument", i.e. focusing the divergent elements of the space program.

The possibility is not precluded that the failed invasion at the Bay of Pigs served to fix the President's decision in stone, and Sidey believes that this may have happened [7]. However, by the time Kennedy revealed his decision to Congress on 25 May to commit the United States to the moonlanding project, the worst images of the Bay of Pigs fiasco had receded from the collective conscience of the American people. The news reports of the speech do not mention any possible influence which the Bay of Pigs might have had on the decision.

To accept the incontrovertible evidence about the actual date and decision making process, which Hugh Sidey and Ted Sorensen provide, enables the historian to create a portrait of the President responding to a major concern In a reasoned manner, on the basis of the best available Information received from his key advisors. In fact, as Ted Sorensen and others who knew the President have related, Kennedy clearly had more goals than beating the Russians to the Moon, including, but not limited to, establishing his place in history. If he could not go to Congress to ask for 20 billion dollars to insure that place or to satisfy his own interest in reaching out to the New Frontier of space, the image of Soviets rather than Americans walking on the Moon would serve his purpose very well.

* * *



Anyone looking up at the Moon knows explicitly that humans have walked on its surface and have looked back at the Earth, floating through the blackness of space. This view of the Earth greeted the Apollo 11 astronauts as they came from behind the Moon after the lunar orbit insertion burn. NASA

Apart from any real or imagined Cold War reasons, what other factors influenced Kennedy's 14 April decision which he revealed on 25 May 1961? According to the late NASA historian Eugene M. Emme [11], the reasons why Kennedy decided that the United States should commit itself to an adventure in space remain unclear. In seeking the roots of the President's choice of space as his means to a place in history, Emme found himself forced to apologise for citing a series of anecdotes in trying to answer the mystery. He acknowledged that:

> "There seems to be something missing in all of the good books about John F. Kennedy to explain fully why he made the stirring speeches that were written, and encouraged those in the space adventure" [11, see p.381].

Obviously, we lack the best source for finding the answers, the President's memoirs. If we accept his public statements, however, Kennedy did not see himself acting alone when he proposed the Moon landing mission to Congress on 25 May 1961: "It will not be one man going to the Moon - if we make this judgement affirmatively - it will be an entire nation". Did the entire nation - and perhaps more importantly, did the US Congress - support the President's commitment to landing a man on the Moon?

Clearly, Kennedy believed his space programme had popular appeal. Writing on 23 August 1962 to David Bell, Director of the Budget, about the proposed cost of building the manned space centre in Houston, Kennedy expressed the concern that despite NASA Administrator James E. Webb's explanation, the budget seemed "excessive". Since funding for the entire programme might be affected, Kennedy warned that costs would need "the most careful continuing scrutiny". He felt that NASA must meet its estimates "more precisely" because the "programme has so much public support that unless there is some restraint there is a possibility of wasting some money" [12].

The President did not explain to Bell why the space programme had "so much public support" or from where it came. However, Kennedy's press secretary, Pierre Salinger, had no doubt that the President had a unique feel for the pulse of the nation:

> "There was nobody that I've ever known who has been President of the United States who had the political instincts of Kennedy. He was really something out of the world. Reagan has them, to a certain extent. But nobody between Kennedy and Reagan has had those kind of political instincts to understand what grabs the American people" [13].

Kennedy may have had a rare ability that enabled him to sense how other people viewed the moonlanding. But, how did the President himself perceive space and the Moon? How did his personal aspirations and the political realities interact to product his decision that the United States should undertake a costly project filled with great risks? Only by looking at the entire matrix of inputs into the President's thought processes can future generations fully understand why he

Kennedy believed his space programme had popular appeal. This photo of the launch of Apollo 11 on 16 July 1969 shows the press viewing area. Nearly 3500 accredited newsmen covered the launch. NASA

decided to commit the United States to landing a man on the Moon.

* * *

No evidence exists to show that Kennedy read science fiction or had any particular interest in space travel as a boy. Former *Washington Post* Editor Benjamin Bradlee, a friend as well as a contemporary to the President, recalled that boys of their generation had a fascination with explorers and exploration. At Harvard, Kennedy undoubtedly had read Frederick Jackson Turner's *The Frontier in American History* and Bobby Kennedy recalled that the President believed that space exploration:

> "compared to the explorers in our own country, Lewis and Clarke, [in] what needed to be done in space. I think that made a profound impression on him".

No science fiction book is included in the Kennedy Library's catalogue that lists books that Kennedy is known to have read and no one the writer interviewed could recall any interest the President had in science fiction literature [14,15].

Initially, the New Frontier which Kennedy expounded during his campaign encompassed far more than a national venture in space. In accepting his party's nomination on 13 July 1960, Kennedy said that:

> "The New Frontier is here whether we seek it or not... uncharted areas of science and space, unsolved problems of peace and war, unconquered pockets of ignorance and prejudice, unanswered questions of poverty and surplus..."

Ultimately however, Ted Sorensen said the President came to consider space as the New Frontier [10].

Given Kennedy's awareness of history and sense of adventure, his decision to pursue a more active space programme than his predecessor should have come as no surprise. That he would choose the Moon as the goal for the United States space effort became virtually inevitable. Both Pierre Salinger and Hugh Sidey agreed that Kennedy came to see himself in relation to the Apollo Program as Queen Isabella saw herself to Columbus' voyages of discovery. In particular, Sidey observed that he had:

> "No question at all that Kennedy had a romantic view of his leadership. He was out there on a stage with DeGaulle and Churchill and all of those people and there is no doubt he felt that he was a person as crucial as Isabella to Columbus" [7,10].

Sidey believed that Kennedy considered himself the catalyst that could launch a major space effort:

James E. Webb being sworn in as the new NASA Administrator on 14 February 1961. NASA

> "I think without question that Kennedy saw this as one of the great epics of mankind, one of the great adventures. I never heard him say it in great detail, but he could just relate it to Columbus, or Hannibal, or Alexander the Great, or you name it".

Sidey did not think that Kennedy's interest in advancing space exploration had much to do with technology, with the gadgets of science or the mathematical calculations of space travel: "He was, as near as I can tell, not a particularly adept man at machines or anything". Rather, Sidey perceived that Kennedy looked on space exploration from an historical perspective, for what it offered to a democracy:

> "He understood that like the railroads, the Panama Canal, the cure for polio, that these were the ingredients of a successful democracy, that people had to have an adventure, had to have something to reach out for" [7].

Mirroring these observations, Theodore Sorensen, Kennedy's top aide, recalled, "It seemed to me that he thought of space primarily in symbolic terms. By that I mean he had comparatively little interest in the substantive gains to be made from this kind of scientific inquiry". According to Sorensen, the lagging American space effort that Kennedy found when he entered office:

> "Was symbolic, he thought, of everything of which he complained in the Eisenhower Administration: the lack of effort, the lack of initiative, the lack of imagination, vitality and vision; and the more the Russians gained in space during the last few years in the fifties, the more he thought it showed up the Eisenhower Administration's lag in this area and damaged the prestige of the United States abroad" [16].

According to Robert Seamans, at a meeting with NASA officials on 21 November 1962 to discuss increasing the NASA budget, Kennedy and Vice President Johnson "were both very anxious to move the manned lunar programme ahead aggressively" and at the meeting the matter arose as to the nation's "true objectives" in space.

The President explained that he felt the lunar landing had become the important objective for NASA. In response, James Webb disagreed, contending "It is to become preeminent in space". When Kennedy asked what he meant, the NASA administrator launched into a discourse on space science and the application programme, advancing technology, and the buildup of the capability of educational institutions in science. In turn, Kennedy observed:

> "Well, that's all very well, but I don't really know that there are many people who feel it's significant to have these kinds of scientific exploits, but I do know that they find that the manned lunar landing and the manned programme do have great significance" [17].

Kennedy nurtured within himself an innate sense of adventure and curiosity about the unknown. He had not read the 1959 United Nations General Assembly "Report of the *Ad Hoc* Committee on the Peaceful Uses of Outer Space" with its observation that manned exploration of space represented a continuity in man's "basic urge to discover and to explore, to go where no man has gone before, to go everywhere man has the means of going". Nor was he to have the opportunity to watch *Star Trek* with its portrayal of space as the final frontier where the crew of the USS Enterprise could "Boldly go where no man has gone before".

Hugh Sidey, believed the wide range of books Kennedy read and the research and writing of his own book, *Profiles in Courage*, created such an awareness. Likewise, Arthur Schlesinger, Jr., saw Kennedy's commitment to the New Frontier as a means of:

> "Pressing the limits of man's knowledge. And Space, I think, in Kennedy's mind probably was the last frontier and part of the general human process by which you move ever forward. I think the conquest of space, the exploration of space, was in his mind, the ultimate objective" [7,18].

Salinger, Kennedy's press secretary, agreed that Kennedy's interest in space had its basis in practical considerations rather than any cultural influence. He thought that the President saw space as a means of regrouping the American people and as vital to the outcome of the US/Soviet competition. However, to Salinger, the President's involvement in space became more than the sum of its parts. Kennedy did not stress the on-going struggle with the Russians but went the other route. By asking the nation to make a commitment to go to the Moon by the end of the 1960s, he put the endeavour:

> "On another plateau which is much more acceptable to the American people. They didn't see it as a polemic struggle with the Soviet Union, even though behind the scenes, we in the government knew that was the prime objective" [13].

* * *

President Kennedy speaks before a crowd of 35,000 at Rice University in 1962 during a tour that included Cape Canaveral and the Marshall Space Flight Center. NASA

To Kennedy himself, however, the international ramifications of the space programme and the competition with the Russians may not have served as the primary basis for his ongoing commitment to a lunar landing, particularly after criticism began to develop against the huge expenditures required to fulfil his goal.

Faced with such attacks, the President clearly needed a deeper sense of the importance of space to sustain the programme than simply beating the Soviet Union to the Moon.

After Kennedy's death, Wernher von Braun asserted that "There is something inevitable about the Space Age, just as there was something inevitable about the Renaissance, or the Age of Steam, or the Air Age". At the same time, the rocket scientist saw the need for and importance of a deeply committed leader in pushing any new endeavour: "...the personal interest that political leaders take in these new contemporary ideas has a great effect on the *speed* at which these new ideas take hold" [19].

Von Braun saw Kennedy as "a man of great vision. To him, space was, as he aptly put it, 'the new ocean on which we must learn to sail'". Perhaps more importantly, von Braun observed that Kennedy "had a genius for sensing the ideas that have captivated the younger generation. It has been said that a man's age is best measured by the degree of pain he feels when confronted with a new idea. In this sense, President Kennedy was a very young man" [19].

Vice President Lyndon B. Johnson, head of the President's Council on Space and the man in his administration to whom Kennedy turned first for information about the space programme, agreed with von Braun's conclusion, albeit with at least a hint

President Kennedy and Vice President Johnson are briefed by astronauts Walter Schirra and L. Gordon Cooper on the Mercury spacecraft during a visit to Cape Canaveral in 1962. NASA

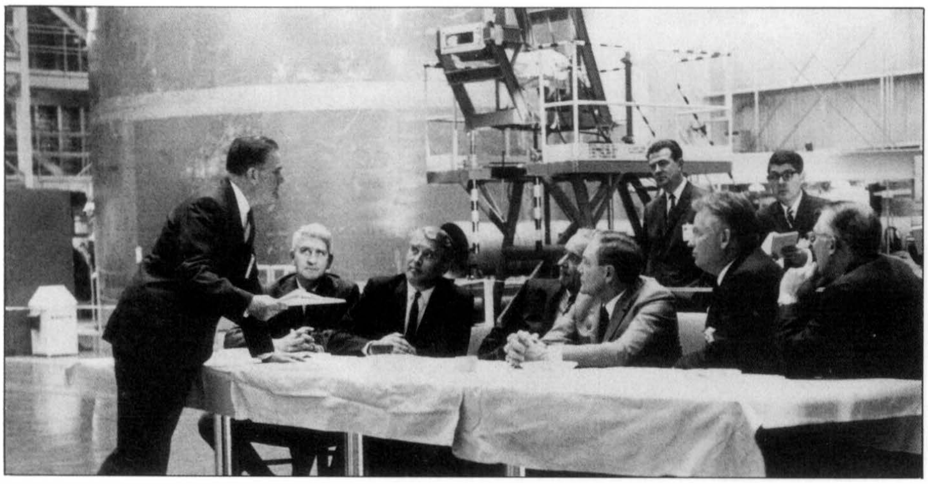
Visiting the Marshall Space Flight Center in December 1967, President Johnson pledges, "We will never evacuate the frontiers of space to any other nation. We will be - we must be - the space pioneers who lead the way to the stars". NASA

of jealousy. Dr Edward Welsh, the Executive Secretary to the President's Council on Space, recalled that the Vice President once told him that the "one thing that Kennedy would be remembered for of all the things he did was his contribution to the space programme". Welsh believed that while Johnson thought he was superior to everyone, he still "was a little envious" of Kennedy for having initiated the Moon landing mission [20].

However history ultimately rates Kennedy and the Apollo programme, his commitment to a lunar landing remains one of his signal achievements. Aside from the public and political judgements of the President's decision to go to the Moon, and however much he saw the success of the goal as assuring his place in history, Kennedy did seem to have had a genuine fascination with space. Otherwise, his own support of the Apollo Program might well have flagged as criticism grew during 1963.

Wernher von Braun observed this personal interest while having breakfast with the President's youngest brother, Senator Edward Kennedy, in February 1963. The junior senator from Massachusetts told von Braun that the President and his brothers "had one favourite topic when they were among themselves and that topic was space flight!". Von Braun was convinced of the validity of the statement because the senator "was very well informed about our programme and asked several questions that were amazingly similar to the questions that the President himself had asked. So I can only conclude there must have been quite a bit of discussion among the brothers on the subject" [19].

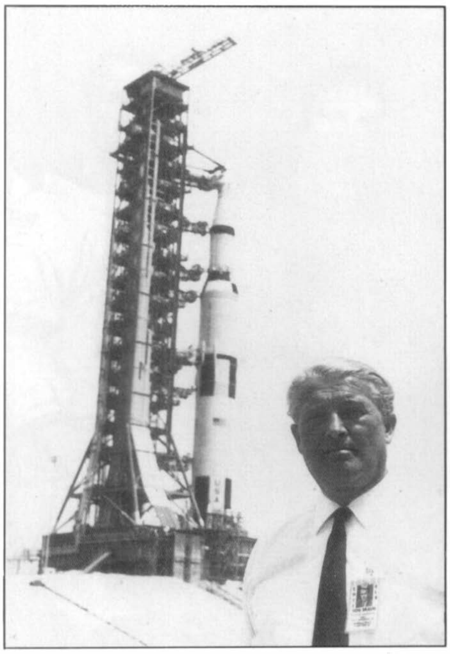
After his speech at the Marshall Space Flight Center in December 1967, President Johnson (seated at the centre of the table) is briefed by NASA Administrator James E. Webb (standing) and others, including Werhner von Braun (to the left of the President as seen in the photo). NASA



Robert Seamans further confirms the President's personal interest in space as the result of a meeting with Jacqueline Kennedy after Kennedy's assassination. Following the first successful test flight of the Saturn I rocket, Seamans had phoned Mrs Kennedy's secretary to find out if the President's widow might want photographs of the launch. Seamans remembers that Mrs Kennedy called back in five minutes to invite him to her house in Georgetown. There and in a follow-up handwritten letter, Mrs Kennedy told Seamans how much interest the late President had had in the space programme, how he used to discuss it with her in private, and how he "always had exciting new plane and rocket models in his office to show [his son]" [21,22].

Nevertheless, it remains difficult to describe precisely how Kennedy's sense of adventure and curiosity about the unknown, his knowledge of history, and more particularly, whatever cultural images of space travel he might have acquired, combined to create his enthusiasm for the US space programme. However the ingredients did interact, they produced his commitment to landing a man on the Moon and then reinforced his decision in the face of growing criticism of the Apollo Program.

The President perhaps best expressed his feelings about space exploration during his last visit to Cape



Von Braun and Apollo 11. NASA

Canaveral, on 16 November 1963, when he told NASA officials, "I think the most significant event that took place in the Fifties was the launching of Sputnik". Emphasising why the United States must go into space, he added, "this was a very important new adventure for mankind and it's important that this country show real leadership in this area" [17].

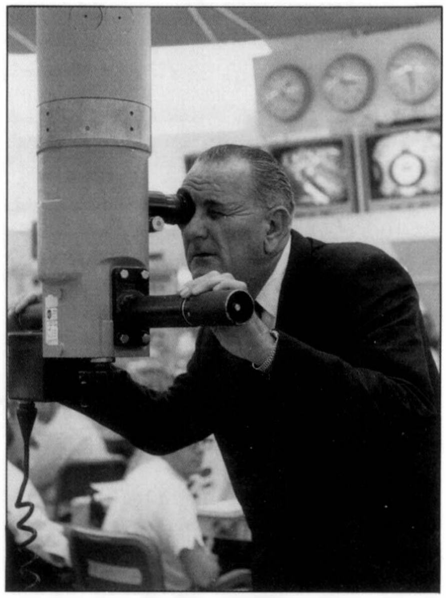
That he just as strongly believed in his decision and the need to carry it through seems clear. On the day he had recommended to Congress that the United States should land a man on the Moon, he told members of his family, "I firmly expect this commitment [of going to the Moon] to be kept. And if I die before it is, all of you here now just remember when it happens, I will be sitting up there in heaven in a rocking chair just like this one, and I'll have a better view of it than anybody" [23].

When such private recollections and observations are combined with the public record, a picture emerges of a John Kennedy committed to landing a man on the Moon, not to beat the Soviet Union alone, not to prove the United States' continuing technological superiority for Cold War purposes, but to unite the American people in a common cause, a positive programme that would stand for all time. As Lyndon Johnson observed, initiating the Apollo program did insure Kennedy's own place In history. Nevertheless, the President could not have gone to Congress seeking $20 billion for a lunar landing simply to gain a few lines in history books. His personal fascination with the exploration of the final frontier provided the necessary catalyst in bringing together all the elements required to create the lunar landing programme and guarantee the nation's commitment to its ultimate success.

Neil Armstrong's "One giant leap for mankind" remains far more than the triumph of the United States or of President Kennedy's commitment to the Apollo Program. The moonlanding symbolises a culminating point in all of history, the coming together of literature, of science, of technology and politics to produce an event that defines man. Before Apollo 11 took off, Wernher von Braun compared the flight to "life crawling on the land for the first time". Following the landing, he went further: "I think historians will really measure this as that. I think the

ability for man to walk and actually live on other worlds has virtually assured mankind immortality" [24].

James Webb had no doubt of the significance of Apollo 11. Asked to compare Apollo to Columbus, he felt certain that in 500 years, people would celebrate the flight in much the same



President Johnson visiting the John F. Kennedy Space Center on 15 September 1964. NASA

way as the world, in 1992, commemorated the discovery of the New World [8]:

> "I think they will realise more how difficult it was to overcome the problems involved as the present and future activities reveal the difficulties. There was a remarkable team of men during Apollo. It will stand out in history as a remarkable feat, absolutely".

Arthur Clarke went even further. Writing during the midst of the dismantlement of the Apollo Program in 1972, Clarke predicted that history would ultimately:

> "...restore the correct perspective. An age may come when Project Apollo is the only thing by which most men remember the United States - or even the world of their ancestors, the distant planet Earth" [25].

Likewise, as Lyndon Johnson recalled with some jealousy, President Kennedy's decision to commit the United States to Apollo and his support for it will undoubtedly become the one thing for which history remembers his presidency. ■

References

1. Walter A. McDougall, *...the Heavens and the Earth*, Basic Books, 1984, p.7.
2. Michael Beschloss, "Kennedy and the Decision to go to the Moon", Paper presented at the Symposium on "Presidential Leadership, Congress and the US Space Program" at the American University, 25 March 1993.
3. Hugh Sidey, *John F. Kennedy President*, A Crest Book, p.110.
4. Hugh Sidey, "Tossing Our Hats Over the Space Wall", *Life* magazine, 6 June 1969.
5. Hugh Sidey, "Adversity made JFK Aim Us for the Moon", *The Washington Star*, 15 July 1979.
6. Correspondence between Hugh Sidey and the late NASA historian Eugene Emme.
7. Interview with Hugh Sidey, 16 October 1986.
8. Interview with James Webb, 23 June 1987.
9. Interview with David Bell, 30 January 1988.
10. Interview with Theodore Sorensen, 2 December 1987.
11. Eugene M. Emme, "Presidents in Space", in Frederick C. Durant (Ed), *Between Sputnik and the Shuttle, New Perspectives on American Astronautics*, AAS History Series, Volume 3, p.42.
12. Theodore Sorensen Papers, JFK Library, Box 38, Subject Files, 1961-64, "Space", (11 June 1962 - 23 September 1963).
13. Interview with Pierre Salinger, 10 September 1986.
14. Interview with Benjamin Bradlee, 12 June 1991.
15. Robert Kennedy, *In His Own Words*, p.340.
16. Theodore Sorensen, Interview with Carl Kaysen, for the John F. Kennedy Library, 26 March 1964.
17. NASA Interview with Dr Robert C. Seamans, Jr, 27 March 1964.
18. Interview with Arthur Schlesinger, Jr., 13 February 1987.
19. John F. Kennedy Library interview with Wernher von Braun, 31 March 1964.
20. Interview with Edward Welsh, 2 February 1987.
21. Interview with Dr Robert Seamans, Jr., 10 February 1987.
22. Letter from Jacqueline Kennedy to Robert Seamans, 14 March 1964, with kind permission of Mrs Onassis.
23. Recollection of Sargent Schriever at launching of Apollo 11, *New York Times*, 17 July 1969.
24. NASA Press Conferences on 14 and 22 July 1969.
25. Arthur C. Clarke, *The Lost Worlds of 2001*, 1972, p.17.

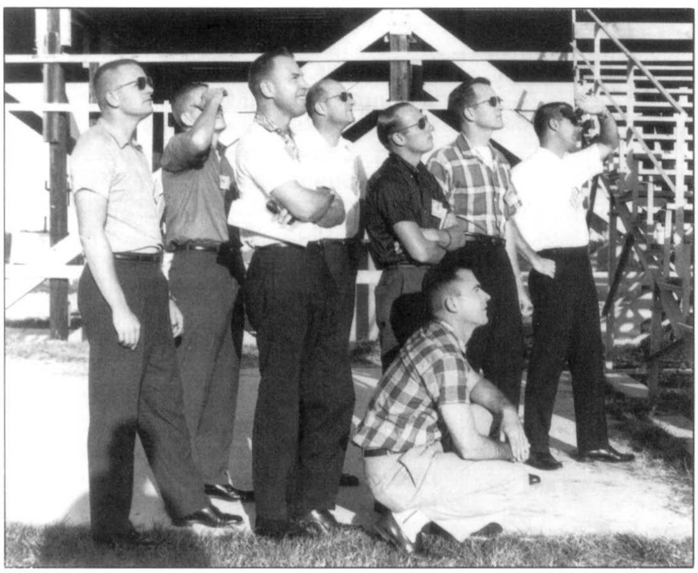
Ed Hengeveld, space flight historian and BIS member, commemorates the 25th anniversary of the first manned lunar landing with this painting of all 12 moonwalking astronauts. ED HENGEVELD 1994

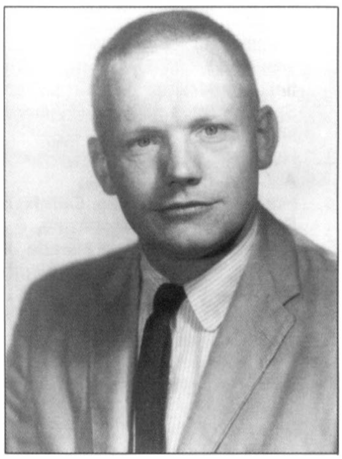
Neil Armstrong

His NASA Career in Pictures

BY ED HENGEVELD
The Netherlands

Neil Armstrong was 24 years old when he joined the National Advisory Committee on Aeronautics (NACA) in 1954 as a research pilot for the Lewis Flight Propulsion Laboratory *(photo right)*. The following year he transferred to NACA's High Speed Flight Station in California to participate in testing some of the early X-planes. His debut came on 25 October 1955 when he made the first checkout flight in the variable-sweep wing X-5. Due to problems the plane was retired after this flight. In late 1957 and early 1958 he made four flights in the rocket powered X-1B before this programme was also cancelled. In 1958 NACA became the National Aeronautics and Space Administration (NASA) and the High Speed Flight Station was renamed Flight Research Center. Armstrong applied for a job as an astronaut and, on 17 September 1962, was accepted as a member of NASA's second group. Eight of these nine men are shown *(photo left)* watching the launch of Wally Schirra on board Mercury-Atlas 8 on 3 October 1962, two weeks after their selection. They are (left to right): Armstrong, Borman, Lovell, Stafford, Conrad, White, McDivitt and (kneeling) Young.





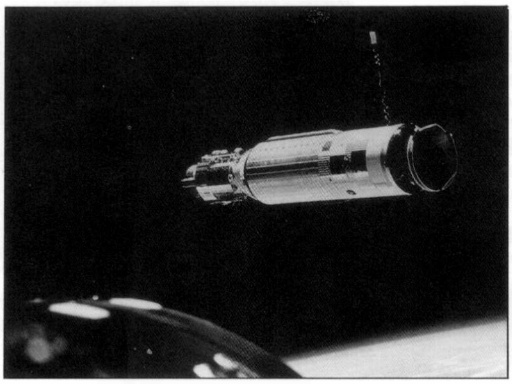
All photos courtesy of NASA

Right: **On 9 December 1960, Armstrong made the first X-15 flight with the Q-ball nose installed. This special sensing device was designed to indicate angle-of-attack and sideslip during the X-15's flight out of and back into the atmosphere. He made a total of seven flights in the airplane between 30 November 1960 and 26 July 1962, reaching a maximum speed of Mach 5.74.**

Lower right: **During this period, Armstrong was also active on the other end of the speed scale, test-flying the Paresev or Paraglider Research Vehicle. This unusual craft was built to study the feasibility of using a deployable, kite-like glider wing as a means of landing a Gemini spacecraft on Earth after it had reentered the atmosphere.**

After initially specialising in trainers and simulators, Armstrong's first crew assignment came in January 1965, when he was named backup command pilot for Gemini-5. Upon completion of that assignment in August, he was named prime command pilot for Gemini 8 with Dave Scott as his pilot.

Six hours after launch on 16 March 1966, Armstrong and Scott successfully completed the first docking of two vehicles in space by linking up to this unmanned Agena target vehicle. However, a malfunctioning thruster on their Gemini spacecraft forced them to make an emergency landing in the Pacific Ocean.

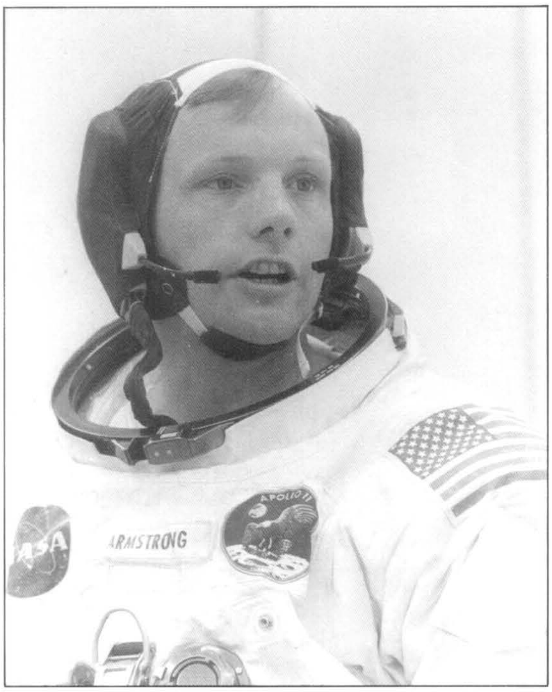


A few days after his return from space, Armstrong was named backup command pilot for Gemini 11. He is shown here standing between prime crewmen Pete Conrad and Dick Gordon shortly before their launch on 12 September 1966. Note that Armstrong is wearing the Gemini 11 mission patch, but with his name and that of backup pilot Bill Anders instead of the names of the prime crew. The sign on the capsule hatch refers to the fact that an earlier launch attempt was scrubbed.

This is a somewhat curious portrait of Neil Armstrong and Dick Gordon, because they never formed a crew together. It was probably made in connection with a goodwill trip to a number of Latin American countries that they made in October 1966.

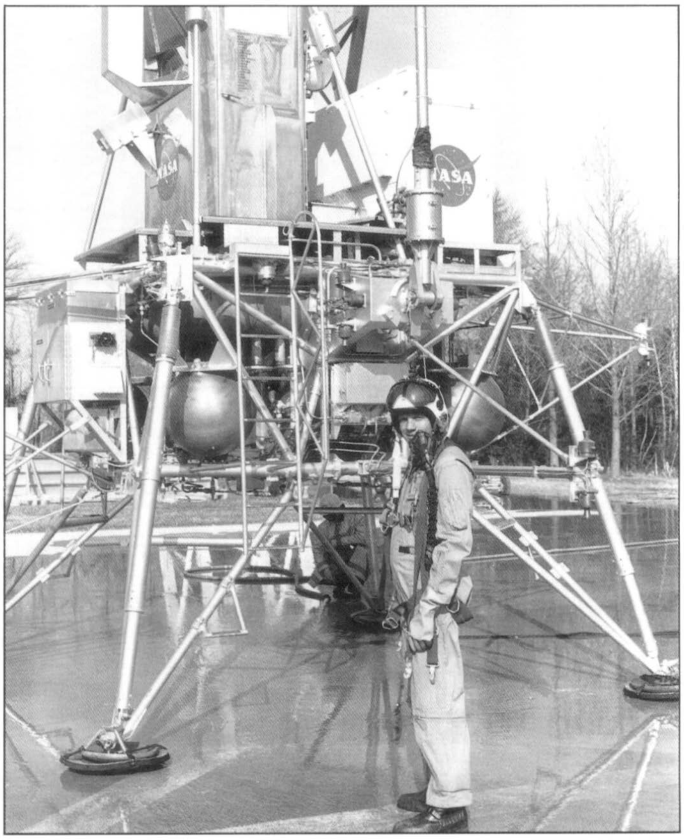
NEIL ARMSTRONG: His NASA Career in Pictures *(Continued)*

Right: **The Apollo 1 fire in January 1967 delayed astronaut training for a while, but in November of that year Armstrong was named backup commander for the third manned Apollo mission, which eventually became Apollo 8. On this flight, astronauts Borman, Lovell and Anders became the first men to orbit the Moon. Apollo 11 was now scheduled to attempt the first lunar landing and in January 1969 Armstrong was named commander of that flight together with Mike Collins as command module pilot and Buzz Aldrin as lunar module pilot.**



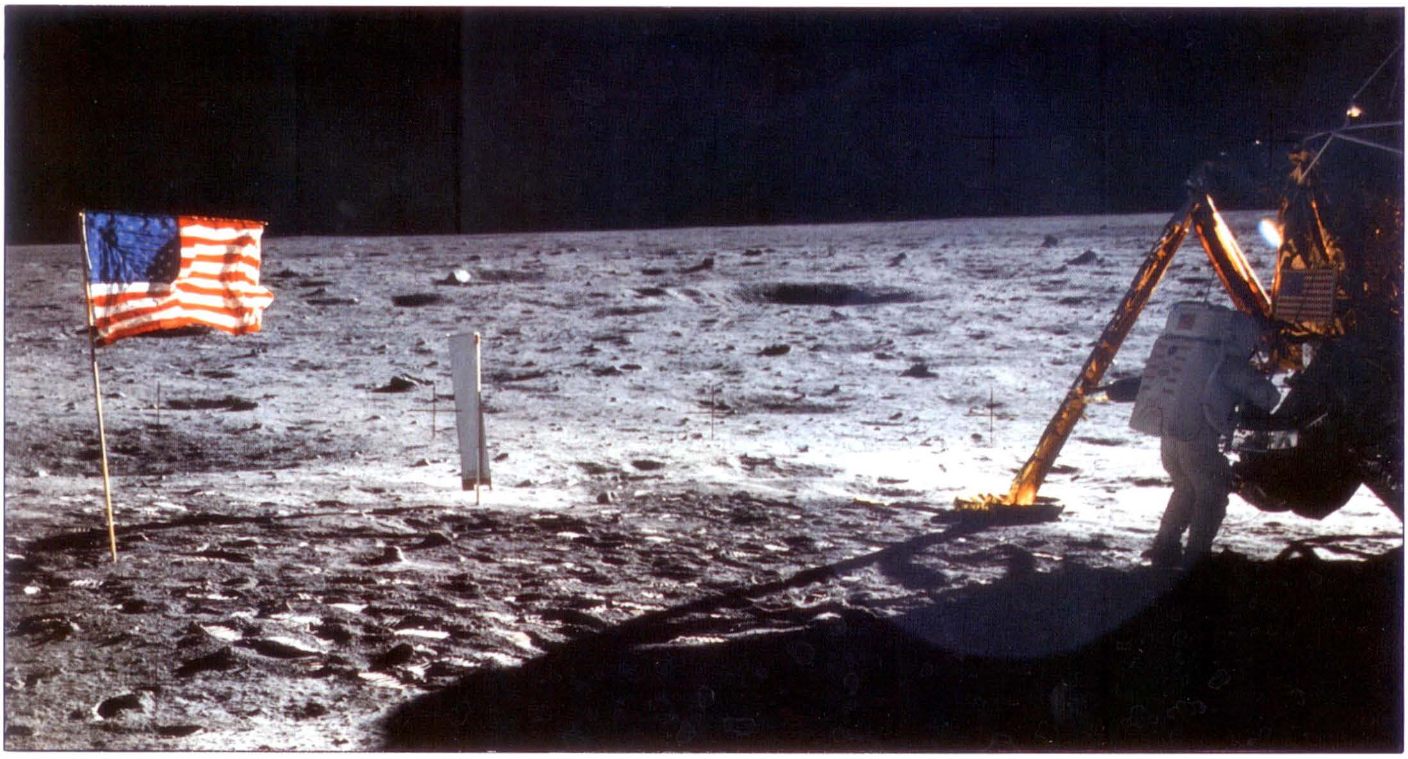
At 9:32 am EDT on 16 July 1969, Armstrong and his crew were launched by an Apollo/Saturn V. Four days later the Apollo 11 lunar module "Eagle" made a successful touchdown in the Sea of Tranquillity. This photo shows Armstrong suited up on the day of the launch.

Below: **A tired but elated Armstrong is shown back inside the lunar module after the surface activities had been completed.**

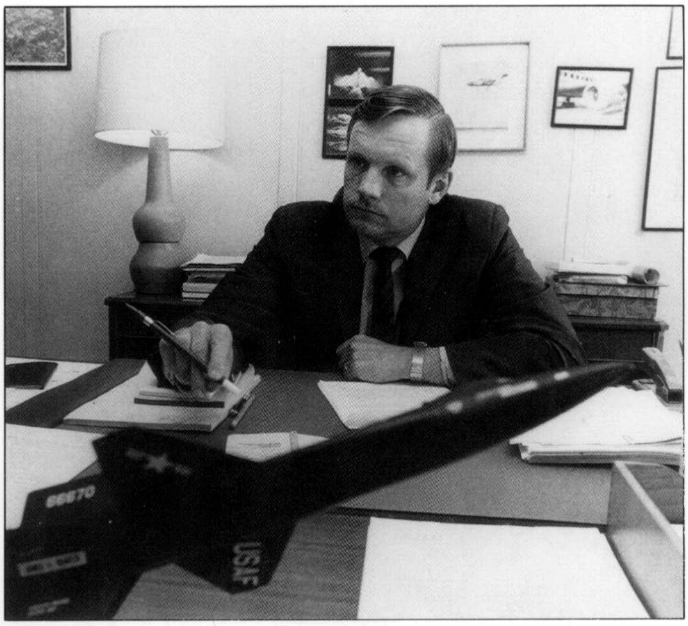


Armstrong is shown here with an important training device known as the Lunar Landing Research Facility at NASA's Langley Research Center in Hampton, Virginia. The LLRF was tethered to a giant support gantry and allowed its pilot to practice the final 50 metres of a lunar landing. Armstrong made many flights in this simulator, as well as in a free-flying version called the Lunar Landing Training Vehicle. In May 1968 he had even crashed one of these trainers, saving himself with his ejection seat at the last possible moment.

Below: Despite the months of preparations, one essential detail was overlooked: nobody had thought of obtaining a good photo of the first man on the Moon. This appears to be the only photograph that shows Armstrong working on the lunar surface; it was taken by accident when Aldrin was shooting a panorama of the landing site.



After their return to Earth the Apollo 11 astronauts were locked up in the Lunar Receiving Laboratory in Houston to prevent possible lunar micro-organisms from contaminating the environment. On 5 August 1969, Armstrong celebrated his 39th birthday in isolation in the LRL.

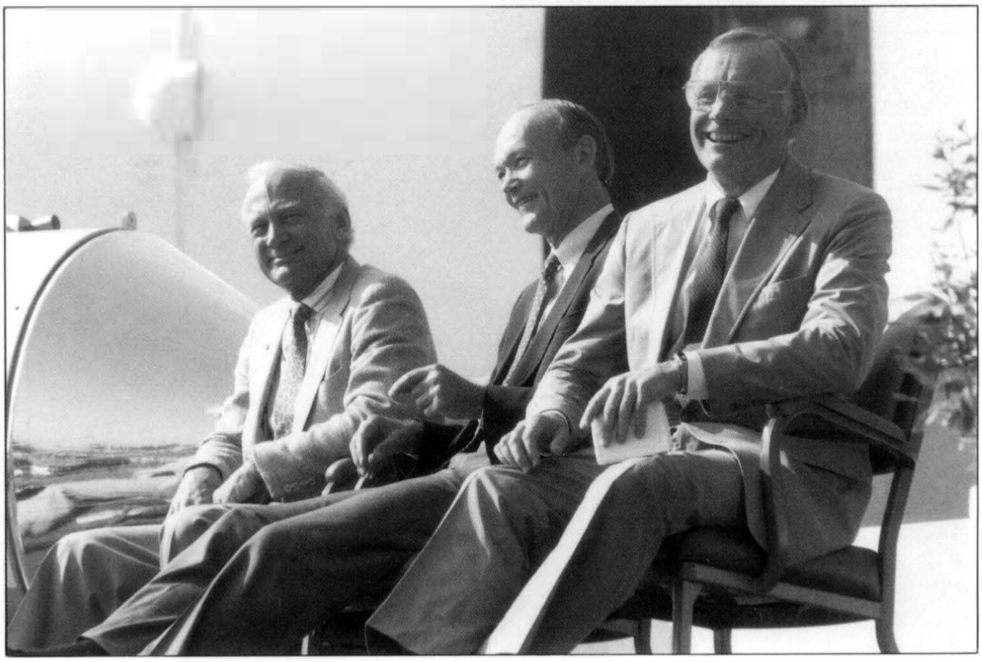


Following a goodwill tour around the world that lasted 38 days and included 29 stops in 22 countries, Armstrong resigned as an astronaut and returned to his first love: aeronautics. On 1 July 1970, he was sworn in as Deputy Associate Administrator for Aeronautics at NASA headquarters in Washington. He is shown here behind a desk on the first anniversary of the Moon landing.

Left: In his new job, Armstrong was responsible for coordinating NASA's aeronautics activities at the various centres. He is seen here discussing the lifting body programme with one of its pilots, Bill Dana at Flight Research Center. Both men were former X-15 pilots.

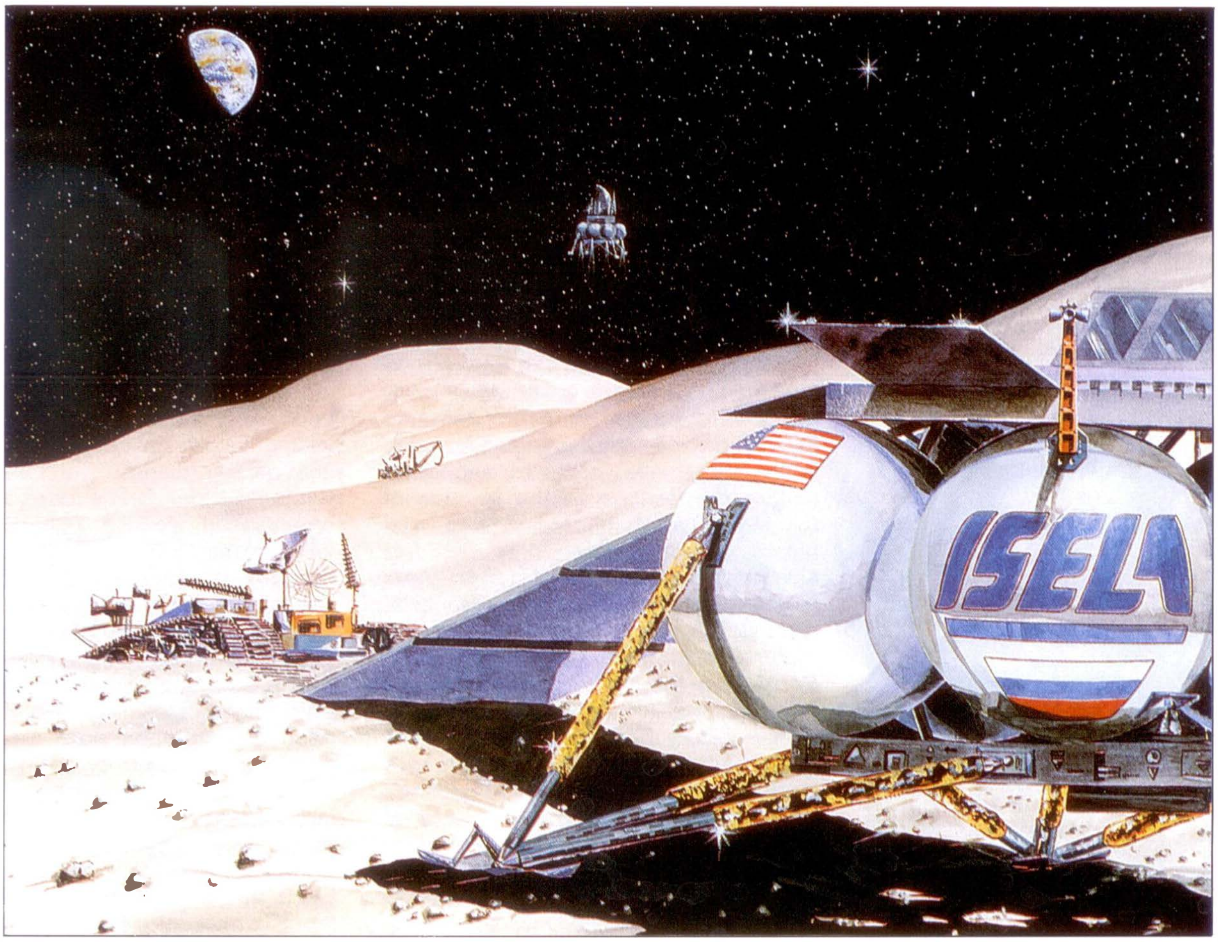
Right: Armstrong did not stay in Washington for very long. On 1 October 1970, he resigned from NASA to take up a position as professor of aerospace engineering at the University of Cincinnati in his home state Ohio. He remained pretty much invisible for the next 15 years and only emerged from this self-chosen seclusion in 1986, when he was named a member of the presidential commission that investigated the Challenger explosion. He is shown here examining the Shuttle Discovery at KSC together with astronaut Bob Crippen (pointing).

Every five years the Apollo 11 crew comes together for a reunion. This photo was taken on 16 July 1989 during the celebration of the 20th anniversary of the Apollo 11 launch at KSC.



International Space Enterprises

Lunar Exploration in the Interests of Science, Technology and Education



ISELA, a US-Russian joint venture, plans a series of privately financed robotic missions to the Moon. © 1993 HUYNH

International Space Enterprises (ISE), a US corporation established in June 1992, is leading an international consortium that will undertake mankind's first privately financed robotic missions to the Moon. In partnership with Russia's Lavochkin Association, ISE has established a joint venture company, ISELA, which is developing systems capable of placing a great variety of scientific instruments, rovers, cameras and other devices on the surface of the Moon.

BY MICHAEL SIMON
Chairman, ISE

Mission Products and Services

ISELA will be producing lunar landing vehicles and "Universal Payload Adapters" that can accommodate several different payloads on each lunar flight. ISELA landers will be flown on the large, highly reliable Proton rocket built by Russia's Khrunichev Enterprises, which has signed on with the ISELA team to become a partner in a US-Russian joint stock company that will distribute profits from these lunar missions. A fourth partner is the Russian firm Zvezda, which will provide the soft-landing systems used on the ISELA landers.

ISE recently concluded a two year proof-of-concept/proof-of-market phase which revealed worldwide interest in returning to the Moon for scientific, educational and entertainment purposes.

ISE will be marketing lunar mission services and integrating customer payloads on to the Universal Payload Adapter (UPA) which it is developing. It offers a range of services, including:

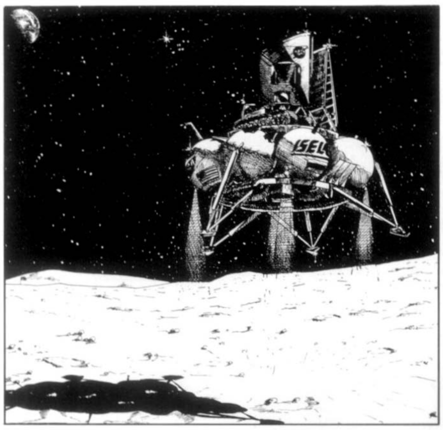
- Design and development of lunar payloads.
- Transportation of customer payloads to the surface of the Moon
- Transmittal of data from customer payload to Earth.
- Provision of power and other services for customer payloads.
- Use of company-owned payloads on a time-share leasing or data purchase basis.

Using existing hardware and commercial management techniques, these services will be provided for a fraction of the cost of conventional space mission approaches. ISE's target price for delivering customer payloads to the Moon is $125,000 per kilogram. The first ISELA lander, whose inaugural flight will be in 1997, will have a payload delivery capacity of 600 kg.

Areas of Application

ISE's broad range of services will attract a multitude of conventional and novel users. Over the past two years, ISE has been assisting potential users to develop lunar mission plans in nine separate areas:

- Lunar-based astronomy
- Orbital remote sensing of lunar surface and environment
- Surface exploration and analysis
- Rover excursions
- Resource utilisation technology demonstrations
- Space power system technology demonstrations



The ISELA-600 lander is scheduled to make its first landing on the Moon in 1997.
© 1993 HUYNH

- Education and entertainment videos and film production
- Virtual reality entertainment
- Novel applications

NASA has encouraged ISE to accumulate a base of private customers to support this project, as NASA is unlikely to acquire funding to lead a lunar programme of its own for many years. Since publicly announcing its venture on 29 September 1993, ISE has been contacted by dozens of organisations expressing serious interest in ISE mission services. ISE has signed memoranda of understanding with a number of these and expects to receive firm commitments for a first landing mission in 1997 by mid-1995.

One scientific market segment with impressive revenue potential is lunar based astronomy. Above the Earth's atmosphere, lunar telescopes would offer astronomers unparalleled views of the Universe. For over a year, ISE has been working with NASA's Marshall Space Flight Center to evaluate the possibility of flying the Lunar Ultraviolet Telescope Experiment (LUTE) on one of ISE's earliest lunar missions. These efforts are presently focused on the development of a low cost variant of this telescope which would be operated commercially and pave the way for later delivery of large telescopes such as the LUTE.

Houston-based Lunar Exploration, Inc (LEI), a non-profit company, has obtained industry commitments to contribute hardware for a Lunar Prospector spacecraft that would remotely gather data on the composition of the Moon from a low lunar orbit. LEI has expressed strong interest in flying Lunar Prospector on ISE's first flight and has recently made progress toward obtaining NASA funding to perform this mission.

Other orbital missions could photograph the Moon with high resolution cameras, enabling the development of more detailed lunar maps and bringing vivid images of the Moon's landscape back to Earth. But the most visually alluring missions will be those carried out on the lunar surface. The piloted and robotic lunar landing missions of the 1960s and 1970s explored only a very small percentage of the Moon, so many interesting features of the Moon remain unseen by human eyes. Many scientists would like to study the Moon up close with devices placed on the lunar surface, which could range from small Instruments weighing as little as 10 kg to large sample analysis or return systems that would weigh several hundred kg.

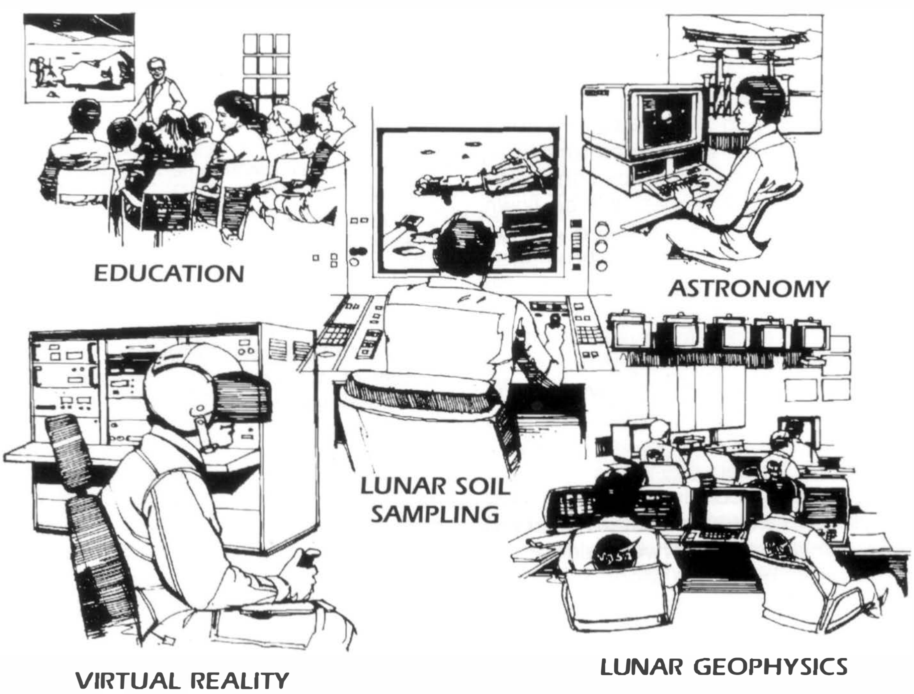
Automated lunar rovers will be key to making new discoveries on the surface of the Moon. One of ISE's first customers, LunaCorp, recently announced its plan to send a large rover to explore several of the old Apollo landing sites, where a variety of generation-old space hardware remains to this day. Another intriguing option is to land rovers, cameras and other exploratory devices on the far side of the Moon, which has never been explored up close. Prior to its first farside mission, ISE will place an inexpensive data relay satellite into orbit around the Moon, which will enable pictures and data to be beamed to Earth from the surface of the Moon's far side for the very first time.

In addition to the scientific pursuits described above, many researchers have interests in conducting technology demonstrations on the surface of the Moon. For nearly two decades, scientists have been particularly interested in the possibility of extracting usable materials from lunar soil, which would be the first step toward true space industrialisation. Numerous experiments have been proposed to process oxygen, hydrogen, aluminium and silicon on the Moon; these are the elements most likely to be used as the feedstock for future space factories. Yet another possibility is extracting helium-3 from lunar materials. This rare isotope, which is thought to be far more abundant on the Moon than on Earth, could serve as the primary fuel for nuclear fusion reactors on Earth by the middle of the next century.

The Moon can also be used as a testbed to demonstrate many different types of space power systems. Because of the intense solar energy hitting its surface during its two week-long daytime cycle, the Moon is an excellent site for experiments dealing with the collection and transmission of solar energy in space. In addition to meeting the energy needs of future lunar outposts, large quantities of lunar solar power might some day be inexpensively transmitted to Earth for use on our planet. The Lunar Power Systems Coalition is one of several organisation working with ISE to develop plans to demonstrate such technologies on ISE missions. The large capacity of ISE's lunar landing system gives it unique capabilities to support large-scale projects.

The scientific and technology development activities just described comprise an important core area for the capabilities offered by the ISELA joint venture. In the long term, however, a large share of this international enterprise may come from entirely new applications. One of the most promising is the emerging field of virtual reality. Stereoscopic cameras, which can return three-dimensional video images from the Moon, can be placed on automated rovers and special vehicles designed to hover or fly over the lunar surface. These images can then

ISE's market consists of traditional scientific users and new categories of customers in areas such as virtual reality.



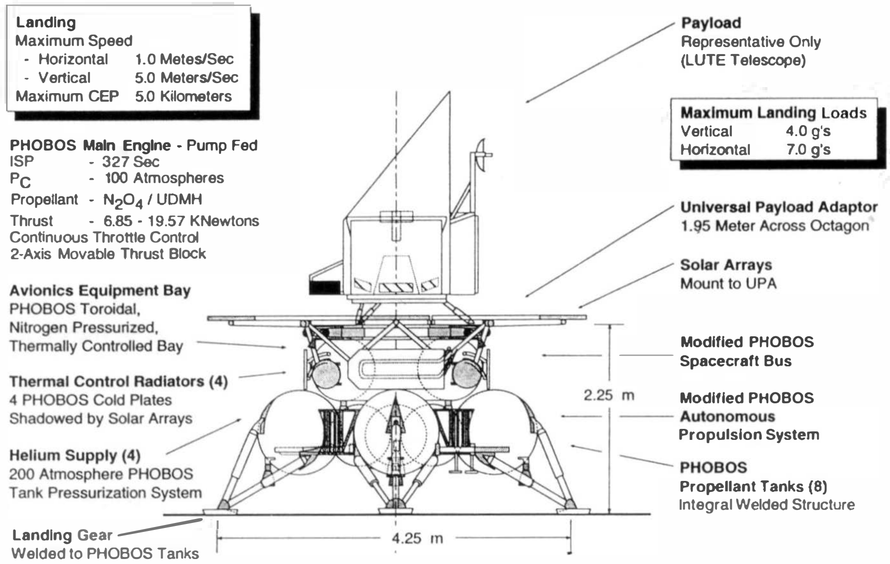
be integrated into virtual reality software and films, providing viewers of the sensation of being on the Moon or flying over its surface.

Bringing the experience of space flight and interplanetary exploration to the general public through these types of media has always been one of ISE's paramount objectives. Aside from the entertainment value of such projects, there can also be a tremendous benefit to education. ISE is presently working with US educators to formulate plans to bring video from ISE missions into classrooms around America. Once established, such an educational "lunar video network" can easily be expanded worldwide. Students may also be offered the opportunity to telerobotically operate rovers and other devices on the Moon. One can only begin to imagine the educational benefits of adding such excitement to the learning process.

ISE is presently seeking corporate sponsors for its educational project and for the ISELA missions in general. Just as corporations have sponsored expeditions on Earth, they might benefit from becoming affiliated with expeditions to Earth's nearest celestial neighbour. During times of decreasing budgets for the world's government space agencies, such private sector involvement is becoming more and more vital to space exploration.

Technical Approach

The ISELA-600 lander which is being designed jointly by ISE and the Lavochkin Association, is a derivative of Lavochkin's proven Phobos spacecraft, a versatile bus used as the core of the Soviet's 1989 Phobos missions and Russia's upcoming mission to Mars.



The ISELA-600 lander is derived from Lavochkin Association's Phobos spacecraft.

Mounted atop each of the ISELA-600 landers will be a new payload support system, the Universal Payload Adapter (UPA). The UPA, to be built in the US by ISE, will provide payloads with power, thermal control, and connections for data processing and communications to Earth. It will be capable of supporting up to fifteen individual payloads on a single landing mission. Users will be provided with interface manuals to help them design their payloads to be easily integrated into the standard interfaces provided by UPA. Optional services such as external power, data transmission, and thermal control will be provided for an additional charge above the base transportation fee of $125,000/kg to the lunar surface.

Payloads for the Moon will be integrated with the UPA in the US after which the UPA and payloads will be encapsulated and delivered to the Baikonur launch facility in Kazakhstan. Here the UPA and its payloads will be mated with its ISELA lander and integrated with the Proton rocket, which will place the lander on its trajectory to the Moon. The launch vehicles and landers will be controlled at Russian mission control facilities, while the UPA and its payloads will be monitored by ISE mission control facilities in the US. After landing on the Moon, UPA and payload operations will be controlled from the US facilities.

A ground and space data network will provide constant communications, with ISELA landers and payloads throughout their missions. Delivery to the Moon will take three days, and payloads will operate on the Moon for durations lasting from a few days to several years. In addition to providing transportation to the Moon, ISE will build its own instruments such as telescope and rovers, which will be leased to users on a "time-share" basis. This will make lunar exploration accessible to those lacking the resources to build and fly their own payloads.

To accommodate very large payloads that are too massive for even the ISELA-600, ISE is designing a larger lander designated the ISELA-1500, which will be capable of delivering 1,500 kg to the Moon's surface. This larger lander is scheduled to become operational a year or two after the first flight of the ISELA-600. Both landing vehicles will use the same UPA configuration for payload support.

Live video from ISELA missions will be transmitted to schools around the world.
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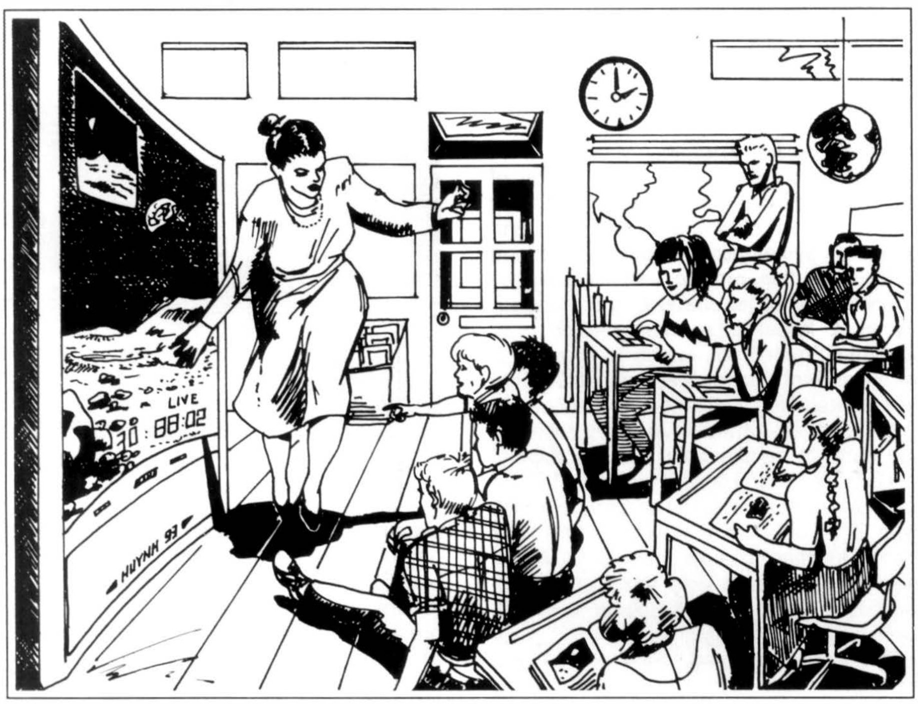


Status of the ISE Project

June 1994 marked the end of ISE's two year proof-of-concept/proof-of-market activity, representing the first phase of ISE's long-term strategic plan. The next phase is a one-year detailed design and planning effort which will extend from July 1994 until

July 1995. During this next phase, ISE and its Russian partners will develop detailed designs of the ISELA-600 lander and UPA, fabricate full scale engineering mock-ups of both of these systems, and finalise all long-term agreements. These accomplishments will set the stage for the hardware fabrication phase, leading up to ISE's first launch to the lunar surface during the second half of 1997.

The ISE venture today stands poised for tremendous success. Within the US alone, ISE had identified enough potential customers to fill all seven missions planned for the 1997-2000 period. NASA personnel have been very supportive, offering technical guidance and expressing hope that ISE will be able to carry many different NASA instruments to the Moon. The public's response to ISE has been terrific; the company has received hundreds of inquiries since announcing its project last September, including many requests for information on employment and investment opportunities. ISE's personnel are thrilled with this response, since one of the company's primary goals is to make the benefits of space exploration available to people around the world, including people who do not ordinarily benefit from space projects.

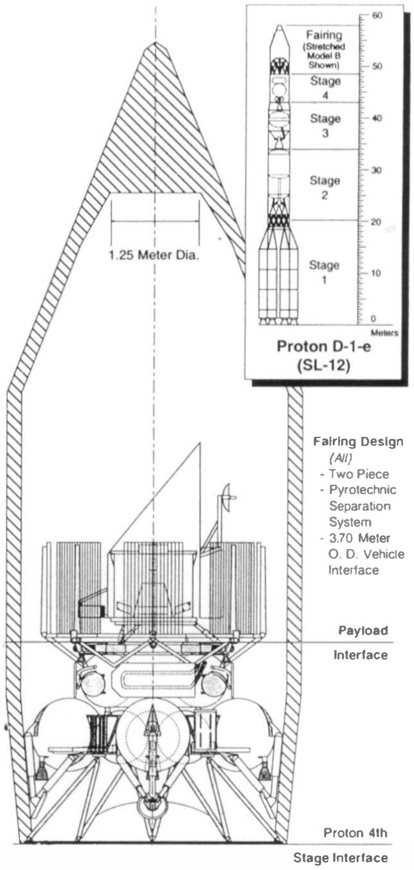
Key Personnel on the ISELA Team

ISE's executive management team consists of aerospace professionals who have devoted their careers to international and commercial space projects.

Chairman and CEO Michael Simon is an ex-NASA employee who worked for General Dynamics for over eleven years and has been active in supporting advanced space projects since 1977. Vice Chairman Larry Bell was a co-founder of Space Industries, International, and is presently director of the Sasakawa International Center for Space Architecture (SICSA) at the University of Houston. He is a Professor of Architecture and is also co-founder and president of the non-profit International Design for Extreme Environments Association (IDEEA).

Leading ISE technical activities is Dr Valery Aksamentov, ISE Vice President for Engineering. He is a specialist in space life support systems and received both undergraduate and PhD degrees in engineering from the Moscow Aviation Institute. Spearheading ISE's marketing activities is David Mazaika, ISE Vice President for Business Development. Mr Mazaika, an engineering graduate of Cornell University, was business planning administrator at General Dynamics Space Systems Division prior to joining ISE. ISE's fifth founding partner is George L. Schuh, ISE Vice President for Finance. Mr Schuh has worked for Sandia National Laboratories and Bell Laboratories and has been involved in research into the commercialisation of near-Earth space since 1972. Rounding out ISE's executive team are Thomas Kessler, ISE Director of System Integration, and Dr Nathan Goldman, ISE General Counsel.

Heading the efforts of Lavochkin Association for the ISELA joint venture is Dr Garry Rogovsky, First Deputy Director of Lavochkin's Babakin Research Center. Dr Rogovsky, a forty-year veteran of the Soviet and Russian space programmes, has made major contributions to nearly all of his country's interplanetary missions, including the Luna, Venera and Phobos. ■



The Proton rocket has ample volume and lift capability to accommodate the ISELA landers and their payloads.

Clementine Maps Moon

"... we have begun a new era in the exploration of the geology of the planets using global multi-spectral data sets" Dr. Jurgen Rahe, NASA Program Scientist

Seventy-one days of Clementine in lunar orbit have provided the first global digital map of the lunar surface in 11 wavelength regions of the visible and near infrared parts of the spectrum.

Surface Composition

By combining information obtained through 11 filters, multi-spectral image data are enabling the distribution of rock and soil types on the Moon to be mapped. Geologic areas which have both impact and volcanic origins, such as the Aristarchus crater and plateau and the Copernicus crater, are being studied for their diversity.

Surface Structure

Laser ranging data from Clementine give nearly global coverage of the topography (or relief) of the lunar surface. These data confirm a population of very ancient, nearly obliterated impact basins, randomly distributed across the Moon and having surprising depths of typically five to seven km even for the most degraded features.

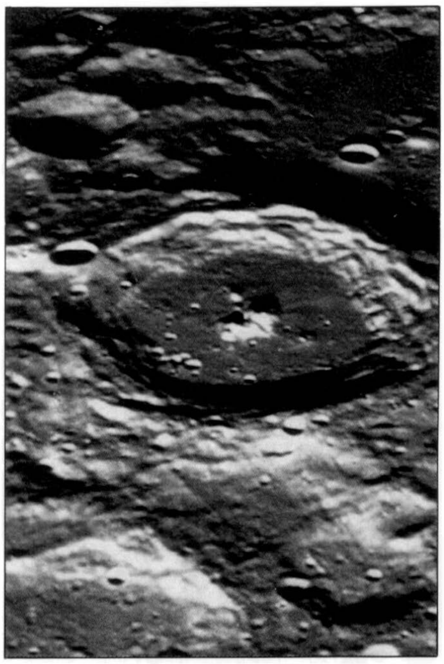
Another major result is the confirmation of the largest impact basin on the Moon, the 2,500 km diameter South Pole-Aitken basin. This feature is over about 12 km deep, making it the largest and deepest impact crater known in the Solar System.

Preliminary analysis has deciphered the gravity structure of a young basin on the limb of the Moon, showing that a huge plug of the lunar mantle has been uplifted from below its surface.

South Polar Ice Trap ?

A mosaic of the South Polar region of the Moon has been completed using over 1,500 images obtained during the first month of systematic mapping. A striking result from this mosaic, depicted by an extensive region of shadow, is the discovery of a large depression centred very near the South Pole, which is thought to be an ancient impact basin about 300 km in diameter. It is believed that large parts of this dark area may never have received any sunlight because the Moon's axis of rotation is nearly perpendicular to the plane of its orbit around the Sun, in which case it is possible that water molecules from impacting comets may have found their way into such cold traps and accumulated in significant amounts over billions of years.

Clementine beamed radio waves into the polar areas and the scattered radio signals were received by the large antennas of NASA's Deep Space Network. This bistatic radar experiment was designed to look for echoes that would indicate the presence of water ice deposits, but the results of this experiment may not be known for many months. ■

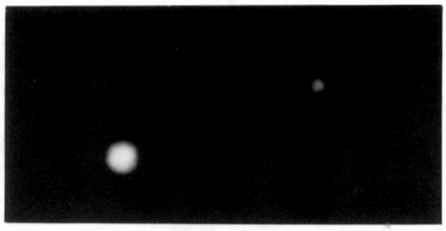


Near the North Pole of the Moon. The large crater is Plaskett at 180°W, 82°N. NRL

Deep into that Darkness Peering

The Case for a 2001 Space Odyssey

Part 2: Origin of the Outer Solar System



Pluto and Charon: this issue p.221.

There are surprising similarities among recently identified objects of the outer Solar System and a number of previously known small but widely separated bodies of the outer Solar System.

The suggestion that these previously known bodies may have originated in a single locale, at a far greater heliocentric distance than any of the major planets, is made more probable by these recent discoveries and makes a space mission to Pluto by no later than 2001 essential rather than just desirable. *(Part 1 of this article appeared in the May 1994 issue, pp.167-171).*

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Relationships and Origins

A comparison of the similarities among the six small bodies known before 1991 is given in Table I. How are we to assess the similarities among these six bodies and the five objects discovered since then. As yet we have no data as to the likely volatiles content and volatiles-age for any of these newly discovered bodies and any conclusions we may draw must be tentative and speculative to some degree. At the moment the data we have relating to all of these small outer solar system bodies is still rather limited in quantity and our knowledge of the probable formation mechanism of the solar system is imperfect to say the least. However, such an analysis can enable us to formulate questions and test ideas that may usefully help towards the construction of a fully comprehensive model for the formation of the solar system.

We can begin our assessment with the observation that the reflectance spectra of Phoebe, Chiron and Nereid, are near identical but that their albedo increases with mean heliocentric distance and probably volatiles content. Two of these small bodies are in highly eccentric capture-type satellite orbits, but appear to have non-captured rotation. The third, Chiron, moves in a moderately inclined and eccentric comet-like orbit and appears to demonstrate comet outburst behaviour that is almost certainly the result of solar heating as it approaches its 1996 perihelion. However, the visual and thermal spectra of Chiron indicate an absence of any significant quantities of bright icy materials at the surface, and so far no evidence of water absorption bands has been found.

French [1] notes that in 1989 S. Allan Stern, (University of Colorado) used the most recent observation data available to calculate sublimation rates of the most common volatiles from a body of Chiron's size and mean distance from the Sun. Stern concluded that volatiles can still be detected escaping from Chiron implies that it has been in its present orbit for only a relatively short time, <300 million years, and possibly for as little as a few times 10^5 years. The molecular species CH_4, CO and CO_2, for example, would be lost almost completely in ~2 x 10^6 years. The implication of Stern's time-scale is that Chiron can have been in something like its present orbit for only a very small fraction of the age of the solar system and it can have completed only ~10^4 to ~10^6 revolutions since it first took up its present orbit. Computer simulation indicates ~0.85 probability that Chiron's orbit has been evolving inwards, most likely from the distance of the Kuiper belt or even beyond.

Chiron would have long ago lost all its volatiles if its mean orbit radius had been close to its present perihelion distance. Given the very close similarities with Phoebe, it seems highly probable that Phoebe was itself a captured Chiron-like object and that it's near constant 9.5 au distance from the Sun has almost exhausted the volatiles and hence terminated any comet-like outburst behaviour such as is occurring with Chiron. Is there evidence of any kind that might support such a conjecture?

Iapetus, the next satellite inwards from Phoebe, which travels a highly inclined (~14.7°) but nearly circular prograde orbit (e = 0.028), has a unique bimodal surface albedo. From the apex point of the satellite's direction of motion the surface is blanketed with a dark slightly reddish material with an albedo range of 0.02 to 0.04. The rest of the surface has an albedo of around 0.5 typical of Saturn's other icy satellites [2]. This peculiar distribution of dark matter on the surface of Iapetus, which overlies cratered and uncratered terrain, has led some astronomers to suspect that the covering material is a dark dust swept up from space, and that Phoebe is the most probable source of the dust. Arguments against this conjecture are that Phoebe is not reddish in colour [3], and the orbital inclinations differ by too large an amount (~9 to 18°) to allow the deposition of phoebian dust on Iapetus. Moreover there is no immediately obvious way to account for so much fine dust from Phoebe being ejected into space by impact processes. Once in space, however, fine dust would be expected to spiral inwards due to Poynting-Robertson drag and could be swept up by Iapetus.

If Phoebe was in the past a volatiles-rich body like Chiron the ejection of dust may not result from impacts but might arise through the operation of a quite different mechanism. Residual traces of volatiles chiefly CO_2, escaping from an almost completely devolatilized Phoebe could provide a means for the ejection of a comet-like dust 'tail'. As dust ejected from Phoebe will spiral inwards in the

Table I: Similarities in Characteristics of the Six Small Outer Solar System Objects Known Prior to 1991.

Characteristic	Phoebe	Chiron	Nereid	Charon	Triton	Pluto
Colour:						
Neutral Grey	yes	yes	yes	yes	part	part
Reddish	no	no	no	no	yes	yes
Orbit:						
Eccentricity	high	high	v.high	zero	zero	high
Capture Type(1)	yes	-	yes	-	yes	-
Retrograde	yes	-	-	-	yes	-
Rotation:						
'p', 'r' or 'c'(2)	p	p	p	c	pc	r
Period days	< 0.5	< 0.5	<~0.5	< 7	< 6	< 7
Diameter km:						
> 200 < 400	yes	yes	yes			
> 750 < 1500	yes					
> 1500 < 3000	yes	yes				
Volatiles/Dust:						
Quantity Present	little	moderate	high?	high?	large	large
Escaping(3) v'tles	CO_2(?)	CO, CO_2	?	CH_4(?)	CH_4, N_2	CH_4, N_2, CO
dust	yes	yes	?	?	yes	?

(1) Orbits with unlikely dynamic parameters eg. retrograde motion, high inclination, high eccentricity, non-captured rotation, etc. Combinations of any or all of these intrinsically unstable characteristics suggest a relatively more recent capture origin.
(2) Indicates captured rotation; pc = prograde captured rotation.
(3) Refers to materials escaping, or able to escape, under the present conditions prevailing on each object.

Table II: Volatiles: Composition and Histories of Phoebe, Chiron, Nereid, Charon, Triton and Pluto.

Body	Albedo	Mean Thermal Flux Range % Earth(1)	Materials Out Gassed	Rate of Loss(2)	Volatile Age in 10^6 yr(3)
Neutral Colour:					
PHOEBE	~0.05	0.99 : 1.25	Dust, CO_2 (?)	Low	< 3.0
CHIRON	~0.08	0.28 : 1.39	CO_2, CO, Dust	Moderate	~5.0
NEREID	~0.12	~0.11	Not known	?	?
CHARON	~0.20	0.04 : 0.114	CH_4 (?)	High (?)	<~100
Reddish Colour:					
TRITON	~0.70	~0.11	CH_4, N_2	Moderate	~1000
PLUTO	~0.50	0.04 : 0.114	CH_4, N_2, CO	Moderate	~1000

(1) Available energy aphelion: perihelion of object. Effective available energy % can be obtained by multiplying these values by (1 - albedo).
(2) Qualitative assessment of current rate of loss against present volatiles content.
(3) Estimated time to lose all volatiles at present distance from the Sun.

retrograde sense it will not settle gently on Iapetus at the low terminal free-fall velocity < 1 m s^{-1} but will impact at ~6.5 km s^{-1}, about twice the satellite's orbital velocity. The effect of this impact energy on the chemistry of a methane containing icy surface may account for the red coloration of the dark material on Iapetus. Rather simplified studies of the collision dynamics indicate that the size and shape of the dark zone are a reasonable match for the expected distribution of collisional deposits given the difference in inclination of the orbits of Phoebe and Iapetus. If this hypothesised scenario could be shown to be correct it would greatly strengthen the idea that Phoebe is indeed a captured body and was in the past closely similar to Chiron and perhaps once had similar comet-like outbursts. The detection of current CO_2 emission from Phoebe would be supporting evidence for such a hypothesis.

The conjecture that Phoebe probably occupied a Chiron-like orbit at one time is an idea that is supported by the present Chiron/Saturn [4,5] encounter pattern. This in turn suggests a similar zone of origin and perhaps the same perturbing agency. It is even possible that the perturbation ages of Phoebe and Chiron are very similar and this has other interesting implications.

Neptune's outermost satellite Nereid is remarkably similar to Phoebe and Chiron in size and mass and reflectance spectrum. The albedo is slightly higher and there is a hint of the presence water frost on part of its surface, which makes the spectrum similar also to that of Pluto's satellite Charon. There is no evidence for current out-gassing but Nereid's orbit and probable non-synchronous rotation suggest capture, possibly within the last few ~10^8 yr.

The mass of Triton, Neptune's largest satellite, is greater than the combined mass of all the other five bodies we are discussing here. Like Phoebe, Triton has a retrograde orbital motion and that, and it's virtually impact crater free surface, are consistent with capture [6]. Pluto is very similar to Triton but only about half its mass. Charon, Pluto and Triton are all very similar bodies whose volatiles compositions differ with mass and thermal environment. Pluto and Charon occupy an orbit that like that of Chiron is chaotic but which at present is in a 3:2 resonance with Neptune.

Overall the picture of the six objects known before 1991 is that they share a chemistry and a pattern of volatiles histories that is not consistent with their present locations within the solar system. It may even be possible that four of them, and perhaps all six, were originally paired up into planet + satellite systems - Pluto/Charon, Triton/Nereid, and possibly even Chiron/Phoebe. The Triton/Nereid combination was somehow disrupted and captured by Neptune, and Phoebe was captured ultimately by Saturn. The orbits of Pluto/Charon evolved inwards bringing them within the zone of the major planets. The volatiles ages of all these bodies (Table II) are short because their very small masses permit quite rapid loss of volatiles even at their present temperatures. So none of them still containing a measurable volatiles content and capable of out-gassing behaviour can have been resident in their present locations for anything much over ~20% of the present age of the solar system. Where did they form, and what perturbed them closer to the Sun?

Although yet only relatively little data has been collected regarding the nature and behaviour of the three outer solar system bodies and the four trans-neptunian and the two trans-plutonian objects discovered since 1991 what is known is accommodated easily within the type of hypothesis we have just explored. We have already pointed out the close resemblance both physically and dynamically between objects 1992AD, 1993HA$_2$ and Chiron. As judged by spectra, and volatiles history, Chiron itself appears to be closely related to Phoebe, Nereid and Charon, and the implication is that 1992AD, and 1993HA$_2$ may be similarly related.

The two trans-Plutonian planetoids share several spectral characteristics with Pluto, Triton the four trans-neptunian dwarfs 1993RO, 1993RP, 1993SB and 1993SC, and with Pholus - object 1992AD. Effectively they all 'share' a wide band outside the orbit of Neptune with the Pluto/Charon binary. Across the eleven objects in heliocentric orbits a tendency for a high value of 'e' to go with a high value of 'i' can be observed perhaps suggesting that these greater values of eccentricity and inclination result from perturbations. Only one of these orbits, that of Chiron, has its aphelion within, and then only barely within, the orbit of Uranus, and it has been calculated that both the period and eccentricity of that orbit are reducing. There is also a tendency for the spectra to be redder with increasing mean distance from the Sun.

From the Kuiper Belt, Planet X or Chaos

The Kuiper Belt: From what we know of orbital histories and the probable compositions of the thirteen objects out to and including Pluto and Charon, we can speculate that they may all have originated in a region of the solar nebula beyond the present orbit of Pluto. Possibly in the Kuiper belt region suggested by Jewitt & Luu as the present home and location of 1992QB$_1$ and 1993FW.

The Kuiper belt was proposed originally as a source of short period comets and the nominal inner and outer limits of the belt have been taken to lie between ~35 and ~100 au from the Sun. The apparently high rock content of Triton, Pluto and Charon, which are estimated to contain ~68 to 80% rocky materials suggests that they are quite unlike the bulk composition of typical comets like Halley.

Although Chiron, a much less massive body than Triton, Pluto and Charon, shows evidence of comet-like out-gassing behaviour its similarity to Charon, Nereid and Phoebe suggests that it to may be made up principally of rock. Moreover, all these small outer solar system bodies, with the exception of 1991DA, contain a volume of material more than one thousand times larger than a comet like Halley, and their masses are probably 2 to 5 thousand times greater. That Chiron, and Pluto at, and near, their perihelia outgas a temporary atmosphere or

The Apparent Relationship of 'e' and 'i' for small Outer Solar System Bodies.

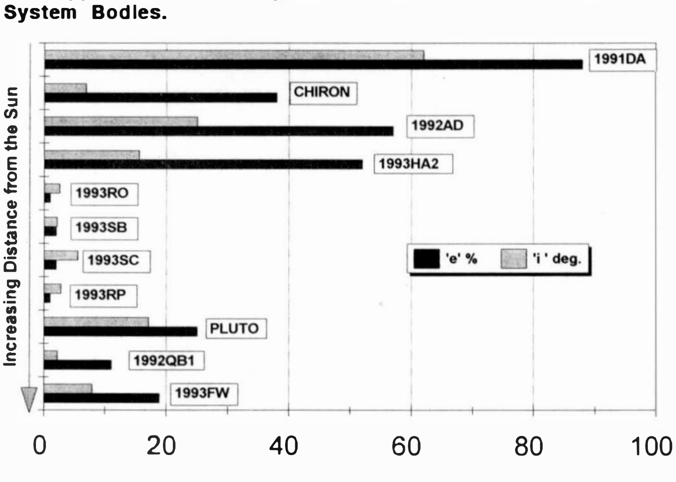


Table III: Calculated Models for Planet X.

Parameter	Harrington 'Humphrey'	Powell 'Persephone'	Gomes Unnamed	Anderson Unnamed
Mass (Earth = 1)	4	0.35	0.49	5
Mean Orbit Radius au	101.2	34.6	44.0	79-100
Period years	1019.0	204.0	292.0	700-1000
Eccentricity 'e'	0.411	0.335	0.05	high
Inclination degrees	32.4	5.43	low	high
Magnitude from Earth	14.0	14.0	14-15	?
Probable Location	Scorpius	Virgo	Cancer?	?

'coma' that is blown away from them to a greater or lesser extent by the solar wind to form a comet-like 'tail' makes them strange hybrids of planetary and cometary bodies. G. Smye-Rumsby, a Fellow of the BIS, coined the apt name *'plomets'* some years ago to describe small worlds of this nature that are made up largely of rock but are rich in volatiles that they are insufficiently massive to retain when heated. Thus the Kuiper belt may be the home of 'plomets' rather than short period comets, if so this tells us something significant about the distribution of the non-volatile refractory materials within the original solar nebula.

Planet X: The unresolved problem is how these small outer solar system bodies became perturbed into the region dominated by the major planets. One interesting possibility is that there really is a Planet X orbiting at a heliocentric distance of ~35 to 100 au. There have been a number of attempts to calculate the mass and dynamic properties of Planet X, four of which were discussed by Mark Littmann [7] in 1988. These proposals were due to Robert Harrington, (US Naval Observatory), Conley Powell, (Teledyne-Brown Engineering), Brazilian astronomer R. Gomes, and John Anderson (JPL). The relevant details are shown in Table III.

Which of these hypothetical models for Planet X would be the best candidate to perturb numbers of small objects into the inner planetary zone? If the six small bodies known before 1991 are all of similar age, $\sim 10^8$ or less, we need a planet that encounters and perturbs objects from the Kuiper belt only at comparable intervals. This would require a large number of orbits to be completed between perturbation events; something essentially similar to the Planet X model Whitmire and Matese (1985) [8] proposed to account for the apparent periodicity in mass extinctions like the K/T boundary event of 65 million years ago.

Such a dynamic configuration would result in short periods of time over which Planet X would encounter and perturb Kuiper Belt objects on nearly every revolution. There would be also very much longer periods when no encounters would occur. Belt objects would therefore be injected inwards in quite narrow time slots and would come to form distinct volatiles-depleted age groups. Once injected and as their orbits continued to evolve inwards their numbers would be reduced continually by impact collisions with planets and satellites. Of the four proposals discussed by Littmann it would seem Harrington's 'Humphrey' is the best candidate. There are also two other good reasons for preferring the 'Humphrey' model for Planet X. The first is that the IRAS (Infra-Red Astronomical Satellite) survey covered most of the sky and no obvious evidence was forthcoming for the presence of a planetary body of any significant size beyond the orbit of Pluto. Only such an object as Harrington's planet could currently lie in the region of the sky not completely imaged by IRAS, so it is just possible that for some reason or other it has not yet been identified correctly.

If there is to be a Planet X the second reason for preferring Harrington's model is the outcome of a current analysis of the orbital 'drift' affecting the planet Uranus. E. M. Standish (JPL) [9] finds that the supposed anomaly in the motion of Uranus, that led some astronomers to postulate the existence of Planet X, vanishes when the accurate masses of the four giant planets, derived from the Voyager fly-by data, are put into the equations. Although there is scatter in the earlier positional data dating back to the discovery of Uranus there are now no longer any systematic trends. Standish concludes that this is just the result of expected measurement errors and there is no reason to evoke a Planet X to account for them. However, if this scatter in the earlier positional data is made up of systematic errors then, as Harrington points out, they could only be caused by a body in a very large radius orbit of high inclination and eccentricity.

Planet X, if it existed, provides a potential way to account for a periodicity in the flux of large impactors within the central solar system. These in turn could catastrophically effect the evolution of life on the Earth as the geological record appears to indicate may have happened. (e.g. As at the K/T (Cretaceous/Tertiary) boundary when it is believed that an asteroid or comet impact caused a mass-extinction of the dinosaurs and a high percentage of all other extant forms of life). The probability that a Planet X exists is very low <0.003% and to account for the present existence of short volatiles-age bodies in the realm of the major planets we need a more certain perturbation mechanism capable of sending trans-Plutonian objects inwards towards the Sun.

Chaos: It has been known for some time that the motions of some solar system objects are chaotic. The orbit of Chiron is an example that was mentioned earlier in this article. Another early and well-documented case is the tumbling motion of Hyperion as it orbits Saturn, (This may possibly be a consequence of a former Chiron encounter). The question is whether it is possible for a system in which all components are coupled, however weakly, to contain single and apparently quite independent instances of chaotic motion. In 1992 Gerald Sussman and Jack Wisdom [10] (Massachusetts Institute of Technology) published the results of a numerical integration of the dynamic evolution of the entire solar system over a time span of ~100 million years. The calculations confirm that taken as a whole the evolution of the solar system is chaotic. Chaotic behaviour holds also for the sub-systems within the main planetary system, the Jovian sub-system for example, although under certain conditions it may be possible for some sub-systems to demonstrate quasi-periodic behaviour. The time scale for exponential divergence of the solar system as a whole is around 4 million years and for the Jovian planets and Pluto the divergence time scale is 10 to 20 million years. Sussman and Wisdom's calculations suggest that there are at least two independent mechanisms generating chaotic behaviour in the solar system. One mechanism generates chaos in the Jovian sub-system (Pluto is independently chaotic in the field of the Jovian planets). The existence of the second mechanism is suggested by the fact that the calculations revealed the simultaneous presence of two different exponential time scales in their full solar system integrations. It is speculated that the secular resonances among the inner planet sub-system may drive the faster time scale.

How does this relate to a possible mechanism for perturbing objects located within the heliocentric limits of the Kuiper belt? Objects like $1992QB_1$ and 1993FW are always more than 8 au distant from Neptune and must therefore escape strong planetary perturbations. The orbits of Chiron, 1991DA, 1992AD and $1993HA_2$ as well as many others between the giant planets, are chaotic on short time scales compared with the age of the solar system. However, there are reasons to believe that orbits beyond Neptune may remain stable for longer times, perhaps for periods approaching 20% of the present age of the solar system, 10^9 years.

According to Hogg, Quinlan and Tremaine [11] dynamic limits allow only a few tenths of an Earth-mass in the form of minor planets or planetesimals in a belt beyond Neptune, but this would permit a significant number of objects to exist within the postulated 65 au wide Kuiper belt. Triton, the most massive possible candidate for an ex-Kuiper belt object, has a mass of only about 0.004 Earth-masses and that is almost twice the mass of Pluto. Either of these bodies contains enough material to form one to two thousand objects the size of $1992QB_1$. So numbers are not the problem the difficulty seems to be perturbing the required flux of objects to maintain ~12 or so bodies in the inner regions of the Sun's family. Perhaps the type of chaotic motion in a primordial comet disk discussed by Torbett and Smoluchowski [12] can provide a

mechanism for sending 'plomets' as well as for short period comets Sun-wards. They found divergence times as low as 1 Myr for cometesimals orbiting in a trans-neptunian belt and calculated that if only 1% of the disk population reached the inner solar system over a period of several hundred million years the annual short period cometary flux would be ~10^2-10^3 yr^{1}.

The injection of trans-neptunian objects into the central regions of the solar system may not form a continuous flux as would be an expected result of long term exponential changes in their orbits. A report [13] of current work by Myron Lecar, Fred Franklin, and Marc Murison at the Harvard Smithonian Center for Astrophysics, has found a curious feature of the chaos of systems where the masses of the objects in the system differed greatly. They discovered that orbit changes tended to occur in small spurts of a few percent rather than in a smooth exponential manner. In other words the planet's motion undergoes small erratic variations for a long time and then it jumps to a slightly different orbit and resumes its previous behaviour. This type of behaviour, like that of the orbit of Chiron, probably means that we cannot calculate the long term orbital behaviour of any of the small outer solar system bodies to establish their past or ultimate future histories. We may have to accept that their injection into the central regions of the planetary system is a certain but largely unpredictable aspect of the chaos in the solar system. However, we can get greater proof of the nature and origin of all the small bodies that we have been discussing by the simple expedient of looking at one of them more closely. One that is still relatively well endowed with volatiles and which is currently in its 'high-temperature' active state, a condition that will cease around 2025 AD and will not be resumed for ~248 years, the planet Pluto.

Mission to Pluto

The neglect of Pluto as an important space mission target was a result of conscious choice. In the early 1970's when the Voyager 1 and 2 missions were being discussed, knowledge of Pluto was sparse. All that was then known was that the planet was a very remote small, cold, and solitary body, and that its size and mass were uncertain within wide limits. On the other hand Titan the largest satellite of Saturn was known to have an atmosphere, believed then to be composed chiefly of methane. As Titan was judged to be of greater scientific interest than Pluto it was decided to take Voyager 1 into a close, rather than a distant, encounter with Titan to image the surface, even though this meant that the option for Voyager to go on to Pluto was lost. (Voyager 2 was programmed for a Neptune-Triton encounter trajectory and the planetary alignments excluded Pluto as a target option.) When Voyager 1 made its close rendezvous with Titan the atmosphere was found to wrap the giant satellite in an opaque red smog that totally obscured the surface. The opportunity to visit Pluto had been traded for a disappointment.

There have been a number of studies for Pluto missions [14,15] but the most recent study for a Pluto Fast Flyby Mission, by Robert Staehle and his team at JPL, [16], offers a much greater scientific potential than Earth-fly-by/Jupiter gravity-assist missions through the 2001 launch windows. The great advantage of the Fast Flyby Mission is that the earlier launch date (~1999), and the shorter flight time between launch and encounter will allow Pluto to be studied almost a decade sooner than 2001 launch window missions.

The scientific reasons for undertaking a Fast Flyby Mission to Pluto as a matter of urgency can be summarised as follows:

- Pluto and Charon are a unique data resource relating to the earliest stages of solar system evolution and of the primordial chemistry and physical state of the pre-planetary solar nebula. These data are essential for developing a fuller understanding of the origin and evolution of the major planets and for increasing our knowledge of the past and future dynamic evolution of the orbits within the system.

- Much of the most important parts of these data are only obtainable when Pluto is in a physically and chemically active state. This occurs only at intervals of ~250 years when the planet is passing through perihelion and is closer to the Sun than the planet Neptune.

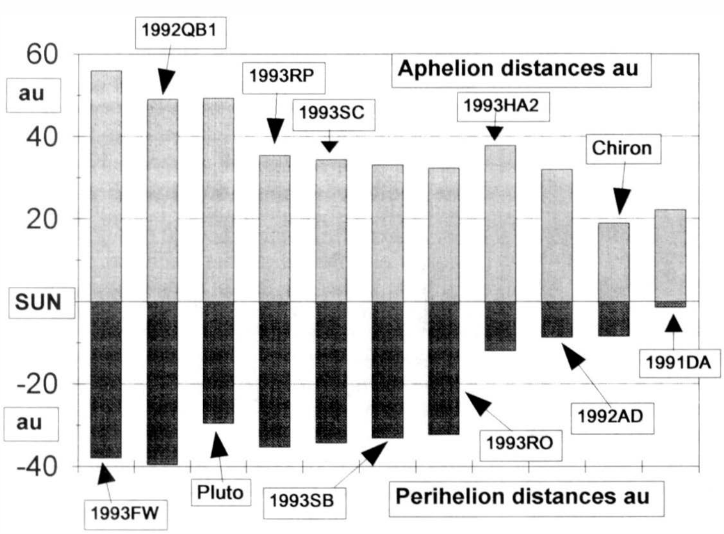
- Pluto is currently moving away from its 1989 perihelion and becoming more remote from the Sun. Estimates suggest that the atmosphere will cease to be active and presumably will have been substantially re-condensed onto the planet's surface by ~2025 AD. Study of the planet in the active state will then not again be possible until 2237 AD.

- The further study of Triton cannot substitute for the study of Pluto and Charon. The images of the surface of Triton obtained by Voyager 2 reveal it to be crater free and shows signs of a once highly active geology. These are the expected signs and result of the stress of capture. Data from Triton is thus in no way equivalent to that which we can expect to gain from a detailed examination of the Pluto/Charon system. The latter is, at it were, much closer to the original nature of the planetesimal bodies which formed at the earliest stage of the evolution of the solar system.

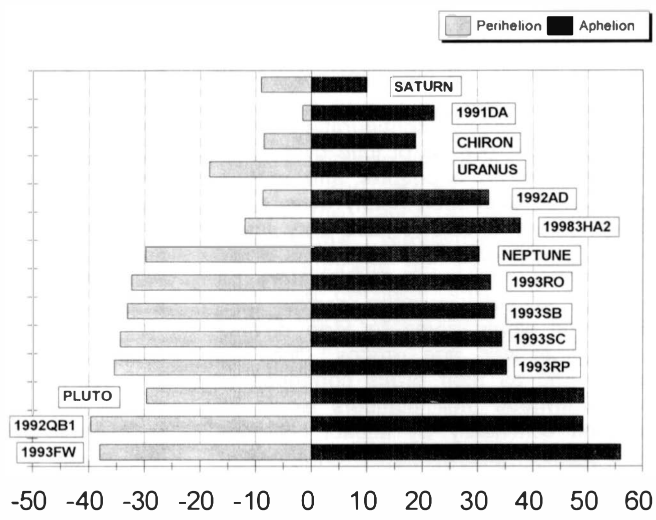
- The relative importance of the Pluto/Charon data in understanding planetary formation and evolution is potentially far greater than the data successfully obtained from Comet Halley by the Giotto mission. Whereas there are many hundreds of comets to which missions can be mounted at any time, and Comet Halley itself can be studied at intervals of 75 years, the Pluto/Charon system is unique and it can only be studied in an active state at intervals of ~250 years.

- The Fast Flyby mission option

Orbits of the 11 small 'Plomets'.



Perihelion Distances of Outer Solar System Objects (au).



Meeting Cosmonaut Georgi Grechko

On 1 April 1994 cosmonaut Georgi Grechko visited Jodrell Bank and met the general public. Grechko flew into space in 1975 to Salyut 4 with Alexei Gubarev and then spent 96 days aboard Salyut 6 with Yuri Romanenko in 1977-78. His final mission to space was the Soyuz T-14 flight to Salyut 7 when Grechko spent about one week in Earth orbit. He logged a total of 134 days 20 hours and 32 minutes in space. While at Jodrell Bank he was interviewed by *George Spiteri* and *Tony Bird* who write about their question and answer session with him.

Georgi Grechko meets the general public at Jodrell Bank on 1 April.

BY GEORGE A. SPITERI FBIS
and
TONY BIRD

S: Mr Grechko, in 1989 I met your colleague Yuri Romanenko with whom you flew into space, so its especially unique to be able to speak to you.
G: We were one of the best crew in space because we only began to argue once. The flight was going so well that I said to Yuri it will spoil our flight!

Every crew that flies into space has an agreement not to argue but not every crew can fulfil that agreement. Our crew was different because most crews train together for years yet we trained together as a crew for only two months (following the Soyuz 25 docking failure in October 1977). In training we became friends and in space we became brothers.

B: Is that one of the reasons Flight Control reprimanded you for working too hard?
G: I am a scientist and we scientists are crazy about our experiments and I worked hard like every scientist in space and Yuri worked with me and helped me.

S: Relating to this mission, could you finally put the record straight about the EVA. Did you rescue Romanenko?
G: No, no of course not. When he jumped out of the space station, I saw that his safety line was unattached. I caught the line and said "Yuri, where are you going?" It was not dangerous at all, the story is pure science fiction. Yuri was very angry about the story.

B: Can I ask you about how you began in the space programme?
G: I was invited as an engineer into the programme. I was young and I entered the Korolyev Design Bureau in 1954 as a mechanic and in 1955 as an engineer. Korolyev knew me personally. He invited engineers like me to take tests to become cosmonauts. I was sure I would be thrown out as a cosmonaut candidate and fail the medical but I was very happy when the physicians passed me.

After entering the cosmonaut team in 1966 I broke my leg. Everybody understood that I would not be a cosmonaut after that. I was very unhappy and as a result I was put to the end of the line to fly and I had to wait nine years for my first space flight but this was my fate. In a curious way it was a good thing because I was back-up on many occasions so I became the best trained cosmonaut!

I was ready to fly on many occasions. The training was very hard. From morning to evening I was training for the EVA and science experiments. Midnight to 2:00 am I had consultations with specialists. At 2:00 am I had consultations with other specialists, followed by exams. I sometimes had five exams in one day from 9:00 am to 6:00 pm. It seems funny now, but it was not funny at the time. I was questioned about the on-board systems. In my time cosmonaut training was important compared with Gagarin's or Nikolayev's time because their spacecraft were basically automated. The physicians monitoring our training were concerned that we were being over-worked and on one occasion the doctor took me out of the exam with the examiner running after me asking yet one final question about the systems!

B: You mentioned training for EVAs. How long did you have to train for the Salyut 6 EVA?
G: My spacewalk was the first spacewalk in a new spacesuit and the original plan was to test the spacesuit by standing on a step (like a stand-up EVA). Due to the docking problem before our mission, the spacewalk had to check the docking unit as well as the spacesuit.

S: Finally, is it true that whilst in space you dreamt of skiing!
G: Yes, most of my dreams were of the Earth and now that you mention it, yes I did dream of skiing. Even now I try to ski such as when I was at Salt Lake City in the USA on a recent lecture tour. ■

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launched in 1999 would reach Pluto in 2006 some nine years sooner that a low energy gravity-assist mission through the November 2001 launch window. The latter would only reach the planet in 2015/16. The plutonian atmosphere will be far more massive and active in 2006 than is likely to be the case in 2015/16 which is only about a decade ahead of the estimated date by which atmospheric recondensation will be virtual completed.

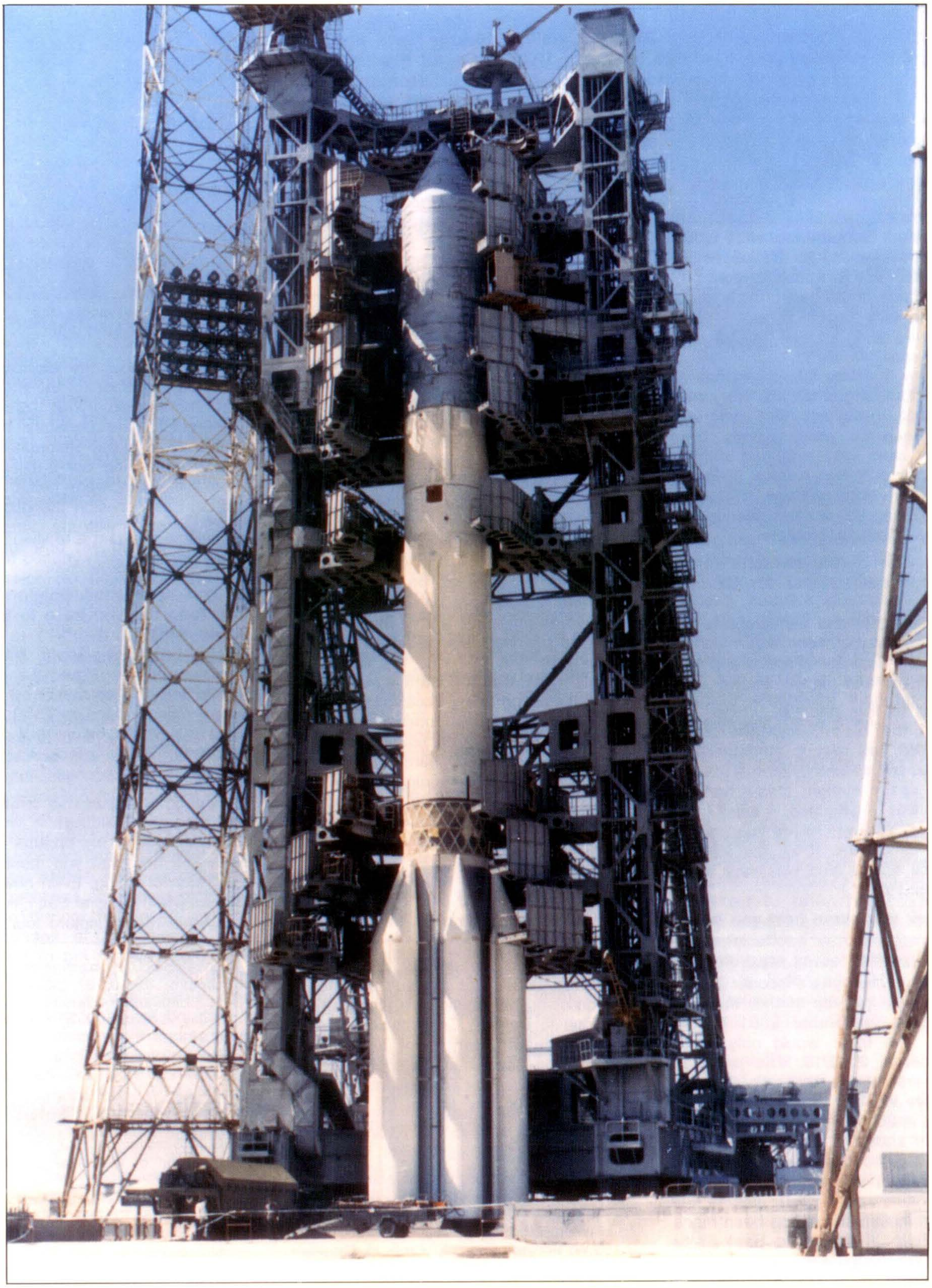
No firm commitment yet has been made to go to Pluto. If the Pluto Fast Flyby Mission is not undertaken, and we miss the 2001 window to reach Pluto, the planet cannot be examined in the active state until it returns to perihelion almost exactly a quarter of a millennium into the future. To avoid this happening we must all exert whatever influence we can to make certain that before and no later than 2001 a space Odyssey to Pluto will be a reality.

Acknowledgements

The author wishes to thank Robert L. Staehle and Richard J. Terrile, both of the Jet Propulsion Laboratory, Pasadena, California, USA, for helpful comments and criticism. My thanks are also particularly due to Dale P. Cruikshank of NASA Ames Research Center for his help in allowing me access to material currently awaiting publication. The author alone is responsible for any errors or inaccuracies that may remain in this article.

References

1. L.M. French *et al.*, Distant Asteroids and Chiron', In *'Asteroids II'*, eds. R.P. Binzel, T. Gehrels, M. Shapley, (Univ. of Arizona Press, Tucson), pp.480-481 (1989).
2. S.W. Squyres and S.K. Croft, In *Satellites* ed. J.A. Burns and M.S. Matthews, (Univ. of Arizona Press, Tucson); p.309 (1986).
3. J. Veverka, P. Thomas, *et al.*, In *Satellites* ed. J.A. Burns and M.S. Matthews, (Univ. of Arizona Press, Tucson), pp.400-401 (1986).
4. C.T. Kowal, W. Liller and B.G. Marsden, In Dynamics of the Solar System, *IAU Symp. No.81* ed. R.L. Duncombe, (D. Reidel, Dordrecht), 245-250, (1979).
5. S. Oikawa and E. Everhart, The past and future orbit of 1977UB, object Chiron; *Astron.J.*, **84**, 134-139, (1979).
6. J.B. Pollack, J.A. Burns and M.E. Tauber, Gas drag in primordial circumplanetary envelopes: A mechanism for satellite capture; *Icarus*, **37**, 587-611 (1979).
7. M. Littmann, 'Planets Beyond', John Wiley & Sons, New York, pp. 195-219 (1988).
8. D.P. Whitmire and J.J. Matese, 'Periodic comet showers and Planet X', *Nature*, **313**, 36-38 (1985).
9. E.M. Standish, Jr *Ast. J.*, **105**, 2000-2006 (1993).
10. G.J. Sussman and J. Wisdom, 'Chaotic Evolution of the Solar System', *Science*, **257**, 56-62 (1992).
11. D.W. Hogg, G.D. Quinlan and S. Tremaine, *Astr. J.* **101**, 2274-2286 (1991).
12. M.V. Torbett and R. Smoluchowski, 'Chaotic Motion in a primordial comet disk beyond Neptune and comet influx to the Solar System', *Nature*, **345**, 49-51 (1990).
13. Reported in 'News Notes', *Sky & Telescope*, **85**, (2), 14-15 (1993).
14. R. Farquhar, and S.A. Stern, 'Low Cost Mission to Pluto' *Planetary Report*, **X**, 28-29 (1990).
15. 'Space at JPL - Pluto Flyby and Neptune Orbiter', ***Spaceflight***, **33**, 421-423 (1991).
16. R.L. Staehle, R. Cassingham, *et al.*, Pluto: Fast Fly-by Mission; ***Spaceflight***, March 1994, pp.101-104 and April 1994, pp.140-143.



ALMAZ-1 on the Launch Pad

Sir, The above photograph shows the Almaz-1 radar satellite on the launch pad at the Baikonur cosmodrome, on top of the Proton launcher still surrounded by its mobile service tower.

As extensively described by Neville Kidger in the March 1994 issue of *Spaceflight*, Almaz is in fact the generic name of a family of military space stations developed by the Chelomei Design Bureau (OKB). As far as I can remember, few pictures of these spacecraft on the launch pad have been released.

This photogrpah was kindly sent to me by Olimply I. Kozlov, Chief Designer at NPO Mashinostroyenia. I also want to thank Theo Pirard, FBIS, for helpful critical discussion.

CHRISTIAN BARBIER
Saint-Georges, Belgium

Space Policy

BIS Early Involvement

Sir, I was reading a book titled "The Sputniks Crisis and Early US Space Policy" by Rip Bulkeley and found a reference to "..the role played by British Interplanetary Society members in developing (early) discussions on unmanned satellites". The footnote references a paper in the Journal of the British Interplanetary Society, Vol. 10, No. 6, November 1951, L.J. Carter Ed.

So we see that forty-some years later, the Society's work of those days is still being cited. The book is recent and, though not a "recreational read", is an excellent source on space policy influences in the 1950s.

ROELOF SCHUILING
Florida, USA

Present US Stagnation

Sir, I get the impression from E. Philpott's letter (***Spaceflight***, June 1994, p.197) that like me, he would like to see a lot more progress on the subject of putting men on the Moon and Mars than we are getting now, even if we differ when it comes to who is to blame for the present stagnation.

I would point out that the plan for putting men on the Moon and Mars submitted by President Bush, the Space Exploration Initiative, was all but laughed out of Congress.

I would also recommend a look at the last paragraph of page 339 of ***Spaceflight's*** Volume 21 (August/September 1979 issue) and the first paragraph of page 340, which are interesting in so much as we have the same situation today, fifteen years later.

As to the points raised on p.197 of the June issue and taken in the same order:

- A classic example of programme stretch-out caused by Governmental attitude.
- Stopping production of the expendable rocket fleet was, as far as I am aware, a political decision and nothing to do with NASA.
- The flaw with Hubble was caused by Contractor error, not NASA.
- I think you will find that "cost-cutting" was behind the modification that may have caused the loss of Mars Observer. The component involved also caused other spacecraft to malfunction.
- The Orbiter Endeavour being wrongly assembled is, I will confess a new one on me, so I will not comment.

One last point, I do not think that starting a new agency will help matters. It will only encounter the same set of attitudes that have hampered NASA for the last fifteen years.

M.M. HUGHES FBIS
Northants, UK

Space Station Support

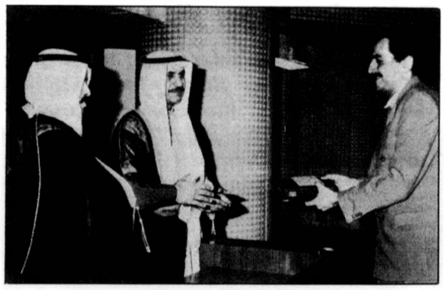
Sir, I have been a Member and then a Fellow of the BIS since the 1960s. I have been a space buff for a lifetime. One cannot be a greater supporter of NASA and manned space flight than I. For all this time I have enjoyed ***Spaceflight*** magazine. Now I feel the time has come to write to you.

As we all know, the US Congress has, at best, fitfully approved the Space Station Freedom concept by increasingly smaller margins. This year the International Space Station will undergo a similar tough battle for funding. The fact that Russia has now joined NASA, ESA, Japan and Canada has created a situation of historical illumination. Perhaps a saving grace for the Station will be the peace between old rivals and the continuance of the Democratic evolution in Russia. A point in space exploration history has now been reached. We must act. We as an international Society must go "all out" to preserve the Station. I urge all readers to contact US Congresspersons. Contact (by phone or letter) ESA and your own government officials to urge and inform about the absolute urgency that the International Space Station be preserved.

The reasoning behind this urgency has, over the years, been elaborated *ad nauseam*. Now is the time to act. If you have never contacted a government official do it now.

Again, a moment in history is upon us. I cannot emphasize the resultant catastrophe, both to the USA and to the world, that will occur to manned space flight if the Station is cancelled. Spacebuffs of the world - UNITE.

HERBERT N. WOLFE FBIS
Florida, USA



Henry Matthews receiving the Best Arabic Scientific Book award from the Kuwaiti Minister of Information.

Book Award

Sir, I am a writer of aerospace historical books and also a 37 year old British expatriate in Beirut, employed in the Information Office of the American University of Beirut. My Encyclopedia of Rocket Aircraft and Space Shuttles was named co-winner of the Best Arabic Scientific Book prize from the Kuwait Foundation for the Advancement of Sciences.

I was recently interviewed by a Lebanese TV station about my book projects and the award. I highlighted in my interview the importance of our Society in spreading awareness of the importance of space exploration among the general public.

I am very happy to be a Member of the Society (since 1990) and I would like to congratulate you on the high quality of ***Spaceflight***.

HENRY MATTHEWS
Beirut, Lebanon

SSME

Sir, I am always surprised to read in reports concerning the US Space Shuttle that its main engines (SSMEs) are throttled to 104 percent power. I wonder why the maximum power they can reach is not simply referred to as 100 percent. Could one of your contributors clear the matter up for me?

I would like to take this opportunity to congratulate you on ***Spaceflight*** and, more specifically, on the quality of the reports published regularly.

JOHN M. GOVAERTS
G.D. Luxemburg

Ed: *Dr Roelof Schuiling at the Kennedy Space Center has kindly obliged with the following reply about the Shuttle's main engine:*

The development of the Space Shuttle Main Engine (SSME) produced an engine that would safely perform in excess of original estimates. The SSME can routinely provide 104 percent power; however, it can go to 109 percent if required in an emergency. Redesignating either 104 or 109 percent as 100 would have required extensive rewriting of documentation and procedures.

Shuttle Re-Scheduling

Sir, I was surprised to notice in the April 1994 edition of ***Spaceflight*** (Forthcoming Space Shuttle Launches, p.119), that the STS-63 Discovery-Mir-Mission is postponed from June 1994 to January 1995!

Now I would like to know, and maybe other readers too, what the reasons of this seven-month delay are?

BRUNO HERBERTH
Nürnberg, Germany

Ed: *The following information is provided by Dr Roelof Schuiling at the Kennedy Space Center:*

Launch planning is geared to a rate of eight Shuttle launches per year. When the STS-58 launch was delayed slightly from September to October 1993, the move placed nine launches in the upcoming fiscal year (October 1993 through September 1994). An analysis of impacts to work in progress, facilities, other missions, and payload status led to the choice of STS-63 to be moved into the next year. This was the minimum impact to the programme. STS-63 will be the first launch of the fiscal and calendar year for the Discovery orbiter.

The Editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

Solo Spacewalks

Sir, I would like to refer to the letter of Mr D.G. Fischer in ***Spaceflight***, March 1994, p.95, about the 'Solo Spacewalks' in the pioneer era of the Gemini and Voskhod programmes. Describing the Voskhod 2 missions, Mr Fischer says that Voskhod 2 commander Belyayev did not have a pressure suit at the time of Leonov's spacewalk.

This is apparently a mistake as both crewmembers spent the whole one-day mission wearing pressure suits. There are many photos and film sequences showing both men wearing their spacesuits during training and when leaving on their way to the launch pad.

It is known that the Voskhod and Vostok reentry vehicles were based on the same spherical module with the same outside diameter. The Soviet political leaders ordered a launch with more than one crewmember to achieve another 'first' before the Americans could launch their Gemini.

Because only Vostok was available Korolyov decided to use it. There were no ejection seats and no pressure suits for the Voskhod 1 crew of three! Voskhod 2 therefore carried only two persons in pressure suits and no ejection seats.

It would be interesting to know if there was any possibility of saving the Voskhod crews in case of a launch failure. There was no Apollo- of Soyuz-type launch escape system on the Voskhod launchers. Does anybody have details?

LAURENC SVITOK
Bratislava, Slovak Republic

Ed: Dietrich Haeseler has been able to provide the following information: Voskhod 2 commander Belyayev did indeed wear a spacesuit of the same kind as the EVA cosmonaut Leonov. A Russian publication of 1974 (Borisenko: *In Outer Space*, NASA TT F-16252, p.41) cites the Chief Designer S.P. Korolyov as saying:

> I can say that if Comrade Leonov runs into any trouble and becomes helpless at any time, the commander himself will leave the ship to rescue Leonov. Our Voskhod-2 makes provision for such a possibility. After putting the ship in the automatic guidance mode the commander can leave it and go to the rescue of a cosmonaut. It is also possible to depressurise the ship for a rather long time, which also greatly facilitates the function of the crew.

This gives the emergency scenario in case Leonov would have become incapacitated. Obviously the ship's systems were able to function *in vacuo* for a certain time. While oxygen for Leonov was normally supplied from a backpack with a redundant supply through the safety tether, it is not clear how Belyayev would have been provided with oxygen. Either there was a second autonomous backpack for him or the only supply for him was through the tether.

The last statement of Korolyov is also not very clear, it could mean that after depressurisation of the whole cabin there were not enough air reserves for repressurisation, and thus the cosmonauts had to remain enclosed in their space suits until after landing.

The risk for cosmonauts wearing no pressure suits inside the spacecraft would have been greater for Voskhod 2 compared to Voskhod 1. In Voskhod 1 the entrance hatch would have been sealed after the cosmonauts' ingress into the cabin before launch and would not have been opened before the spacecraft was back on Earth. Voskhod 2 had a hatch from the cabin to the airlock, which had to be closed hermetically in space after the EVA manoeuvre without support from outside.

The Russian manned Moon landing programme would have been much more dangerous since it contained a truly 'solo spacewalk' on the Moon's surface. No-one could have come to the help of a stranded cosmonaut. He would have to have returned to his cabin, be launched back into lunar orbit and docked to the lunar orbit complex (LOK) by his own means. The LOK was the only spacecraft able to be inserted into a trajectory back to Earth, re-enter the atmosphere and land. The lunar cabin did not have enough propellant to return directly to the Earth, nor did it have heat protection for atmospheric re-entry. This was also true for the Apollo Lunar Module, but this could most probably have been flown by one of the two pilots that it carried.

I do not know of any statement about rescue possibilities in the event of a launch failure. The cosmonauts had no ejection seats and the time needed to use the third stage of the launcher to carry the spacecraft away may have been too long and the thrust was too low to lift the combination of spacecraft, aerodynamic shroud and full third stage off the lower part of the launcher. No failure of the launch vehicle was allowed for and the consequences would have been a disaster for the crew. This was a result of the urgency with which the Voskhod missions were arranged in order to launch the first multi-person spacecraft and to perform the first spacewalk earlier than the American Gemini programme.

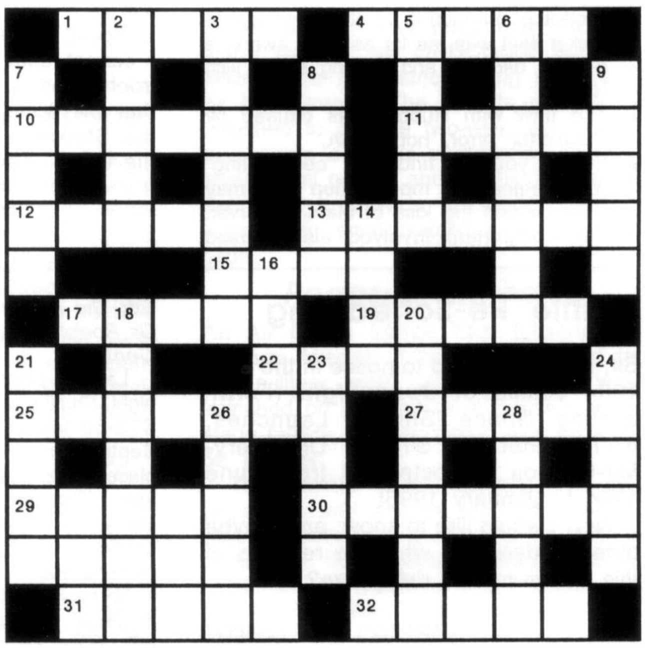
Ed: The Voskhod 2 EVA and technical details relating to the capsule's special inflatable airlock will be described by Dietrich Haeseler in an article to be published in ***Spaceflight*** *shortly.*

Spaceflight Crossword

No. 11

ACROSS
ACROSS
1+4. The —— —— Treaty
4. See 1. Across
10. Bat Isle (ana.)
11. Name for a canny girl ?
12. Quotient
13. Shuttle payload for radar calibration
15. Read jumbled
17. Found in the cash
19. Each of several
22. Fasten
25. Idea
27. Polite
29. Era
30. Small satellite
31. Minimum
32. Awry

DOWN
2. Overturn
3. Interesting incident
5. Coins
6. US upper-stage booster
7. End rocket flight prematurely
8. Levelled area
9. Romany
14. Profound
16. Joint project of USA and USSR in 1975
18. Comforting item in the Control Room ?
20. Quantities with direction
21. Sloping mass of debris from a landslip
23. Very small particles
24. Planet
26. Moral significance
28. Worth



Solution will appear in the August issue.

Solution to Crossword No.10.
ACROSS: 1. Voskhod; 5. Craft; 8. Coast; 9. Seeping; 10. Outflow; 11. Musci; 12. Sunset; 14. Unsung; 17. Roust; 19 Ukraine; 22. Exteme; 23. Slope; 24. Spent; 25. Artemis. **DOWN:** 1. Vacuo; 2. Spartan; 3. Hotol; 4. Disown; 5. Crewman; 6. Aries; 7. Tugging; 12. Serpent; 13. Entreat; 15. Uniform; 16. Eureca; 18. Untie; 20. Rosat; 21. Evens.

Galactic Debris?

Sir, Let me draw your attention to a new and more efficient approach to SETI than the classical search for radio signals. It is known that space activities lead to a lasting pollution of the Solar System [1]. The spontaneous ejection of artifacts into the interstellar medium is inevitable because:

(a) Light pressure expels micron-sized debris particles (e.g. from jet engines) out from the Solar System;
(b) A considerable part of any large artifacts would be ejected by gravitational interaction with the planets (similar to the "Pioneer-10, 11" and "Voyager-1, 2" probes) [2,3];
(c) Collisions between artifacts in the outer parts of the Solar System could accelerate their debris up to hyperbolic velocities.

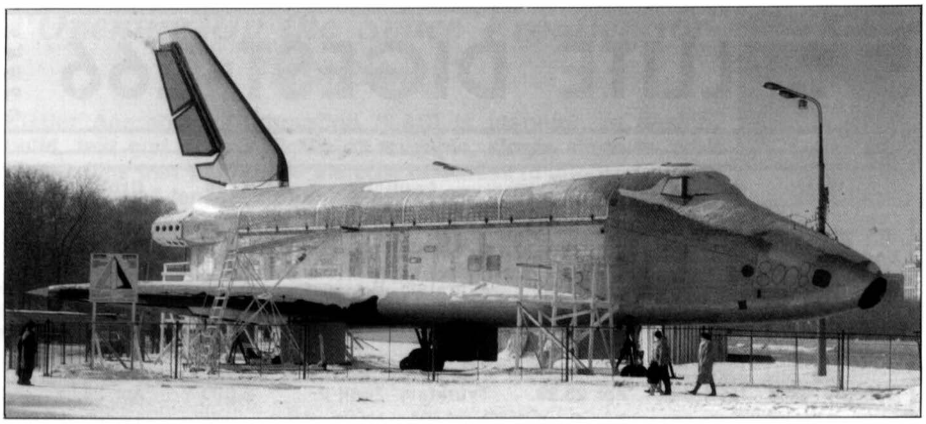
Hence, technical activities even within a planetary system lead to diffusion of artifacts into the interstellar medium. Of course, the direct pollution of interstellar space is possible too. These processes could have taken place in other planetary systems during the previous 12 billion years of the Galaxy's lifetime. If there are alien artifacts between the stars, some of them are likely to fall down to Earth at some time. Disintegration of artificial satellites to debris of different chemical composition appears as multicoloured bolides. Such phenomena were unknown in meteoric astronomy before 1957. However I have found that rare multicoloured bolides had been observed before that time too [4,5]. Moreover, there are other signs of possible falling alien artifacts: reports about puzzling formations ("pseudometeorites") which fell from bolides [5,6]; and "fossil artifacts" found in prehuman layers [7].

Therefore, it is reasonable to explore the deposits of meteorites in the Antarctic Continent and Australia. We could collect exhibits for the Galaxy museum and estimate the upper limit of the number density of alien artifacts in the interstellar medium.

A.V. ARKHIPOV
Institute of Radio Astronomy
Kharkov, Ukraine

References

1. H. Heusmann, ***Spaceflight***, **35**, No.6, p.182, 1993.
2. J. Eberhart, *Science News*, **135**, p.191, 1989.
3. S.K. Vsekhsvjatskiy, in *Problems of Cosmic Physics*, **13**, Vischa shkola, Kiev, p.141, 1978 (in Russian).
4. G.C. Flammarion, *l'Astronomie*, **41**, Mai, p.230, 1927.
5. W.R. Corliss (Ed.), Handbook of Unusual Natural Phenomena, The Sourcebook Project, Glen Arm, p.114, 500, 1977.
6. Ch. Fort, The Book of the Damned, Abacus, London, p.129, 1974.
7. W.R. Corliss (Ed.), Ancient Men: A Handbook of Puzzling Artifacts, The Sourcebook Project, Glen Arm, p.651, 1978.



Fate of Buran

Sir, In March of this year I had the opportunity to travel to Moscow as part of a NASA delegation working with the Russian Space Agency on the design of the new International Space Station.

One Sunday morning one of our interpreters took me to Gorky Park where I saw a very sad sight. One of the flight worthy Buran space shuttle airframes had recently been moved to Gorky Park and was being converted into ...an ice cream stand!

I was told that this is one of the three flight worthy airframes manufactured but that this particular vehicle had never flown. The titanium airframe was stripped of most but not all of its thermal tiles and was covered with snow and plywood while other pieces of the orbiter lay strewn about the ground. A very sad end indeed for such a promising programme.

TODD F. BREED
Texas, USA

'Apollo Missions' Competition

Momentous years in the history of lunar exploration were those of the Apollo Program in 1969-72. As the 25th anniversary of the first manned lunar landing is reached, Apollo missions are taken as the focus of this month's competition with an invitation to find the missing names from the clues provided.

Prizes: The first correct entry to be opened after the closing date of 4 August 1994 will receive a copy of the book:

History of Rocketry and Astronautics
By Lloyd H. Cornett, Jr, Editor

This 452-page book presents many interesting accounts from the early days of rocketry to the Apollo Program with personal recollections and new detailed information. It is published for the American Astronautical Society by Univelt Incorporated, PO Box 28130, San Diego, California 92198, USA. Soft Cover $40. Hard Cover $60.

Four consolation prizes are offered of the book:

Citizens of the Sky
By BIS Fellow Bob Parkinson

To Enter: Supply the four missing names, each of which can be grouped with those preceding it:

1. Snoopy, Charlie Brown, Gumdrop, ...
2. Intrepid, Antares, Falcon, Orion, Challenger, ...
3. Mattingly, Duke, ...
4. Steno Crater, North Massif Mountain, ... Crater

Title/Name ....
Address ....
....
....

Post to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England
To arrive by first delivery on 4 August 1994.
Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

SATELLITE DIGEST-266

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Endeavour	1994-020A	Apr 9.46	KSC	Shuttle	100,566	Apr 9.67	57.00	88.88	213	225	[1]
Cosmos 2275	1994-021A	Apr 11.33	Tyuratam	Proton-4	1,300 ?	Apr 12.27	64.82	675.68	19,114	19,143	[2]
Cosmos 2276	1994-021B				1,300 ?	Apr 28.11	64.81	675.81	19,060	19,203	
Cosmos 2277	1994-021C				1,300 ?	Apr 11.81	64.78	675.68	19,111	19,147	
GOES 8	1994-022A	Apr 13.25	ER	Atlas-1	2,105	Apr 27.54	0.49	1,434.00	35,298	36,193	[3]
Cosmos 2278	1994-023A	Apr 23.29	Tyuratam	Zenit-2	9,000 ?	Apr 24.68	71.01	101.97	849	855	[4]
Cosmos 2279	1994-024A	Apr 26.05	Pesetsk	Cosmos-B	825 ?	Apr 27.46	82.95	104.73	957	1,007	[5]
Cosmos 2280	1994-025A	Apr 28.68	Tyuratam	Soyuz	7,000 ?	Apr 29.46	70.38	89.98	241	306	[6]

NOTES

1. STS-59 mission, carrying six astronauts: S.M. Gutierrez (commander), K.P. Chilton (pilot), J. Apt (mission specialist, MS-1), M.R. Clifford (MS-2), L.M. Godwin (payload commander and MS-3) and T.D. Jones (MS-4). Major payload for the flight was SRL-1 (Space Radar Lab), mass 9,697 kg plus support equipment, mass 1,096 kg, which remained in the orbiter's payload bay. Landed at Edwards Air force Base April 20.70
2. Three Uragan navigation satellites in the GLONASS network.
3. Satellite called GOES I (Geostationary Operational Environmental Satellite) prior to launch: remote sensing satellite, part of NOAA's programme. Planned for location over 270° initially, 285 °E when operational.
4. Large ELINT satellite.
5. Parus military navigation satellite. Launch announcement named the launch vehicle "Cosmos 3M".
6. Fifth generation photoreconnaissance satellite, operating with Cosmos 2267, launched last year. Launch announcement named the launch vehicle "Soyuz V".

ADDITIONS AND UPDATES

In recent months it has become clear that the Two-Line Orbital Elements which are used as the source for orbital data for Satellite Digest have been less accurate than anticipated concerning the location of some geosynchronous orbit satellites. Satellite locations and re-locations are reported in Satellite Digest as accurately as possible, and sometimes the errors in the Two-Line data do not become apparant until a few months after the errors have appeared.

1976-063A Orbital data for Comstar-D 2 indicated that on February 4.44 the satellite was located over 283 °E, and the next Two-Line data issued for February 19.14 showed the satellite drifting in a 1,440.44 minutes orbit over 212 °E: the time interval and the observed drift rate are inconsistent with the observed longitude change, although element sets issued through to April 27.39 confirmed that satellite was still in a drift orbit, drifting to the west at about 1 °/day.

1982-106A DSCS-2 15 was boosted off-station over 59 °E in late January. The location of the satellite was stabilised over 64-65 °E approximately February 25.

1983-058A The comments made concerning the location of this satellite were based upon incorrect sets of Two-Line Orbital Elements being issued. Data issued in March 1994 consistently showed that the satellite is located over 47-48 °E, and not over 65-66 °E as erroneous Two-Lines issued during January and February had suggested.

1983-065A Galaxy 1 was boosted off-station over 226-227 °E during March 7-9, and was still drifting to the west at the end of April.

1983-077A Telstar 301 was boosted off-station over 264 °E in early March: by late April it had been re-located over 252-253 °E.

1984-113B ARABSAT 1D (originally Anik-D 2) has had conflicting orbital data issued during 1994. During February Two-Lines were issued showing that the satellite was over both 19 °E and 279 °E: data during March and April consistently showed the satellite over 19 °E, and therefore this is the most likely location of the satellite.

1985-048B Approximately March 4 Morelos 1 was boosted off-station over 246 °E: it was still drifting to the west at the end of April.

1988-063B According to the Two-Lines, EUTELSAT-1 F5 was re-located from 17-18 °E to 21 °E during February 9-11.

1989-020B METEOSAT 4 was manoeuvred off-station over 359 °E during the second half of February and in late March it was re-located over 350-351 °E.

1989-067A In late February or early March Raduga 24 began to drift off-station over 44-45 °E: by the end of April the satellite had reached 52 °E and was probably dead.

1990-091A A small orbital re-location of SBS 6 appears to have taken place during February 13-22, when the satellite was manoeuvred from 260-261 °E to 264-265 °E.

1991-015B METEOSAT 5 was manoeuvred off-station over 350 °E during Jan 11-21 and was re-located over 359-0 °E in mid-February.

1992-088A Approximately March 30 Cosmos 2224 was manoeuvred off-station over 335-336 °E: approximately April 21 the satellite was re-located over 11-12 °E.

1994-016A Navstar 24 is co-planar with Navstar 20. Add the following orbital data: April 18.51, 54.93°, 718.03 minutes, 20,017 km, 20,350 km.

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-65	8 July	Columbia	13 Days	IML-2*	28.5
STS-68	Mid August	Endeavour	9 Days	SRL-2	57.0
STS-64	Early Sept	Discovery	9 Days	LITE, GBA	57.0
STS-66	Late Oct	Atlantis	10 Days	Atlas-3, Crista-SPAS, SSBUV/A	57.0
STS-63	January	Discovery	8 Days	Spacehab-3, Spartan-204, CGP/Oderacs-2	51.6
STS-67	January	Endeavour	13 Days	ASTRO-2	28.5

*Japan's first woman astronaut, Chiaki Mukai, will be a member of the crew.

Planets, Stars and Orbs: The Medieval Cosmos 1200-1687

E. Grant, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1994, 816pp, £45.

Medieval cosmology was a fusion of pagan Greek ideas and biblical descriptions of the world, especially the creation account which appears in Genesis. Because cosmology was then based on discussion of the relevant works of Aristotle, the prime responsibility for its study during the 13th to the 17th century fell on scholastic theologians and natural philosophers in the universities of western Europe. This work describes that extraordinary range of themes, ideas and arguments that constituted scholastic cosmology for approximately five hundred years, from around 1200 to 1700.

Up to the late Middle Ages (*ca.* 1200-1500), Aristotelian cosmology met little opposition or challenge and by the time rival interpretations appeared in the 16th century, Aristotelian cosmology was firmly entrenched.

By the 17th century, however, Copernican heliocentric cosmology and the geoheliocentric variant of it, as proposed by Tycho Brahe, offered significant alternatives and thus challenged medieval Aristotelian cosmology as never before. How the scholastic natural philosophers of the 16th and 17th centuries responded to these new interpretations is an important aspect of this study.

Collins Dictionary of Astronomy

V. Illingworth, Harper Collins Publishers, 77-85 Fulham Palace Road, Hammersmith, London, W6 8JB, 1994, £8.99.

When one considers how space exploration has progressed in the last few decades, not only by manned spacecraft but by instrumented deep space probes, it is not surprising to find that specialised terms used in space technology and astrophysics have also expanded.

To help keep up with these, this dictionary provides definitions and explanations for over 3,500 terms and is thus a completely revised and updated version of the first edition published in 1979.

Here one will find descriptions of current theories on the origin and evolution of the Universe, the birth and death of stars and the formation and distribution of galaxies. It also includes observational techniques, instruments and laboratories, both ground-based and space-borne.

Star-Hopping: Your Visa to Viewing the Universe

R. Garfinkle, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1994, 329pp, £16.95, ISBN 0-521-41590X.

The sub-title of this book, "Your Visa to Viewing the Universe" is amply borne out by the fact that, even with a small telescope, one can see a multitude of galaxies with billions of stars. The problem faced by every beginner is, however, how to get started?

This book sets out to provide a guide to the heavens in easy stages, beginning with recognition of simple star patterns and moving on, in a series of steps, to identify objects lying in the far Universe.

Star-hopping is a technique which uses easily-found bright stars as markers by which to steer a celestial path leading to interesting fainter stars, star clusters and distant galaxies. Every beginner in astronomy has to learn these skills but few books give real guidance on how to relate the baffling views seen through the telescope to a map in a star atlas.

The heart of this book is a series of 12 monthly star-hops. Two or more tours are given for each month of the year, though many more can be tried later. One chapter, for example, is devoted to the "Messier" trip, which involves trying to see, in a single night, more than 100 bright galaxies, star clusters and gas clouds.

The book explains how to read star charts, find celestial direc-

These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

tions, understand types of telescopes and when to add special filters to cut through haze and light pollution.

This is all basic information but, to get the most out of the book, one must possess either a good quality pair of binoculars or a small astronomical telescope.

The World Aerospace Industry: Collaboration and Competition

K. Hayward, Duckworth & RUSI, 48 Hoxton Square, London, N1 6PB, 1994, 225pp, £30.

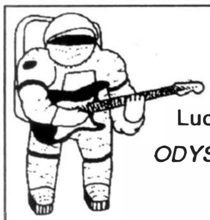
Aerospace is a major high technology industry of particular importance to space exploration. It is a vital element in national security and world transport and has great political significance. Recent years have also shown it to be a focus of intense trade rivalry and a cause of concern to many governments sensitive about their national and regional competitiveness in the world economy.

The aerospace industry has always existed in an environment characterised by uncertainty and dynamic change, but none foresaw the extent to which this occurred over the past few years whereby the industry has seen its traditional markets shrink and has had to come to terms with a completely new situation.

The aerospace industry is currently facing a difficult decade and a continuing bleak future may lead to the creation of more trans-national enterprises, with fundamental implications which will affect the previous pattern of State support for R&D and weapons procurement. In this context space, already an important part of the world aerospace market, is facing its own pitfalls and problems.

This book is concerned with analysing the world's aerospace industry, its structure, market, trends and relations with the State since the end of the Cold War, highlighting the changes which have taken place.

The author concludes that, despite increasing levels of interdependence between national industries, competitive pressures still trigger bitter and potentially mutually damaging conflicts.



'Space Music' Competition

Lucky readers to whom a copy of the book:

ODYSSEY, The Authorised Biography of Arthur C. Clarke
by Neil McAleer

will shortly be dispatched are:

G. Buckley, Lancs, UK P. Kemp, Sussex, UK

The correct answers are: B; C; B; A.

Apollo 11 Moon Landing

on CD

(Due for release in July)

Live studio broadcasts from BBC Television covering the Apollo 11 mission to land the first men on the Moon.

From take-off at Cape Kennedy to splashdown in the Pacific, 16-24 July 1969.

With special, newly recorded commentaries by Arthur C. Clarke and Patrick Moore.

Available from:

- All record stores in the UK and USA (around $16) (Pearl: GEMM CD 9136)
- Pavilion Records, Sparrows Green, Wadhurst, East Sussex, TN5 6SJ. Telephone: 0892-783591 (at £10.50 post free in the UK).

Sales of this CD (released by arrangement with BBC Enterprises Limited) will benefit the work of the aid agency ***Feed the Children.***

JBIS

The July 1994 Issue of the Journal of the British Interplanetary Society is now available and contains the following papers:

S.O.S. and D-2 Spacelab Operations

A Survey of the German Spacelab Mission D-2

•

Planning and Co-ordination of Space Shuttle Attitudes and Trajectory for Spacelab Mission D-2

•

Payload Data Coordination

•

The NASA/GSOC DATA Transfer System for the Second German Spacelab Mission D-2

•

Telemetry Processing for the Second German Spacelab Mission D-2 at the German Space Operations Center

•

Telescience Operations Support on Spacelab D-2

•

Voice Communications in Mission Operations Control Centers

•

TV Operations from the German Space Operations Center (GSOC)

Issues for the previous 11 months are as follows:

	1993
Terraforming (Part IV)	*August*
Extreme Ultraviolet Explorer Mission	*September*
Soviet Astronautics	*October*
The Impact of Space on Culture	*November*
General Issue	*December*
	1994
Exobiology (Part III)	*January*
Space Missions and Astrodynamics (Part I)	*February*
History of Rocket Development	*March*
The Earth-Space Environment (Part I)	*April*
Pioneering Rocketry and Spaceflight (Part IV)	*May*
Advanced Rocket Tehnology	*June*

Copies of JBIS, priced at £17.50 (US$32.00) to non-members, £5.00 (US$9.00) to members, post included, can be obtained from the address below. Back issues are also available.

The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England.

CLASSIFIED ADS

APOLLO 11 Memorabilia for sale. SAE brings list. D. Heatly, 14 Lenamore Park, Jordanstown, Co. Antrim BT37 0PD, N. Ireland.

SPACE BOOKS, journals, magazines, newsletters. FREE lists, Geoffrey Falworth, 15 Whitefield Road, Penwortham, Preston PR1 0XJ.

CLASSIFIED ADS may be placed by Society members at the rate of 53p per word inc. VAT (non-members £1.06 per word inc. VAT). All classified advertisements must be pre-paid. Cheques and postal orders should be payable to the British Interplanetary Society.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: All Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight/JBIS*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

APOLLO 11

25th Anniversary Celebration

with special guests

Buzz Aldrin (Apollo 11 Astronaut)

Capt. Robert F. Freitag (Director, Field Center Developments)

at

The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1

at 6.30 pm on 13 July 1994

The Society is to mark the occasion of the first manned landing on the Moon twenty-five years ago with a special evening buffet reception in collaboration with Cray Electronics plc. Short presentations will be given by speakers who were closely associated with the Apollo 11 mission.

Admission is by ticket available in advance from the Society: Price £15.00.

Accommodation is limited and admission is restricted to members of the Society. Tickets will be issued on and after 1 July 1994. (Please note that this date has been extended from that previously given). If the number of applications exceeds the accommodation available, allocations will be by lottery.

6 July 1994 — 7 - 8.30 pm

Life Support in Space and Lessons for Earth

R. Huttenbach

The talk will describe the features of systems used to sustain astronauts when they live in space.

The technology of biological life support and the evaluation of how closed a system should be, or can be, provide important insights into how we might use resources on Earth.

7 September 1994 — 7 - 8.30 pm

What Must We Change For Low Cost Space: Management, Politics or Technology

C.J. Elliott

Early space programmes were cheap and effective, whereas a mission like Envisat takes 15 years and costs 1500MAU. This lecture examines the drivers that force up the costs of space missions and seeks different ways of behaving that might lead to a virtuous spiral of falling costs and shorter development programmes.

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

6 October 1994 — 7 - 8.30 pm

The First Manned Lunar Landing Spacecraft: Its Design, Manufacture, Ground Test and Mission

R. Fleisig

The Apollo 11 space vehicle is described with emphasis on Lunar Module 5 (LM-5). Development tasks, including test articles and facilities are explained. Manufacturing flow and extensive ground testing phases are detailed. Finally the mission itself with the LM trajectories, important events and key astronaut activities are reviewed.

2 November 1994 — 7 - 8.30 pm

Chinese Space Programme

P. Clark

Interest in China's low-key space programme has increased since the mid-1980s when Chinese launch vehicles were offered for commercial use, as was space on their recoverable satellites for microgravity experiments. Phillip Clark, who has followed the Chinese space programme since its first satellite launch, will review the programme's history, look at the current status of the programme and try to predict in which directions we can reasonably expect the programme to continue.

SYMPOSIUM & CONFERENCES

29 August - 1 September 1994

Practical Robotic Interstellar Flight: Are We Ready?

Venue: New York City

New York University
(9am - 5pm on four days)

The UN
(evening 30 August)

Technical Sessions

1. Interstellar Flight Concepts
2. Spacecraft Engineering Considerations
3. Extrasolar Planetary Systems
4. Intermediate Prestellar Destinations

Cosponsored by the Society in conjunction with 11 other organisations.

15 September 1994 — 10-4.30 pm

Space Transportation and Infrastructure

This one day symposium will include papers on 'The Skylon Spaceplane', 'The Architecture of the Space Infrastructure with Advanced Spaceplanes'.

Advance Registration is necessary. Limited undergraduate student concessions available on request.

Registration: **Forms are available from the Executive Secretary. Please enclose a sae.**

9-14 October 1994

45th IAFCongress "Space and Cooperation for Tomorrow's World"

The 45th Congress of the International Astronautical Federation will be held in Jerusalem, Israel, October 9-14, 1994. There are 98 technical sessions planned. Details of the Programme are available from the Society. Please enclose a 19p stamp.

Hubble Repair Mission Astronaut

Claude Nicollier

at

The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1

at 4 pm on

Saturday, 24 September 1994

ESA Astronaut and BIS Fellow Claude Nicollier will talk about his work and the Hubble Repair Mission of December 1993.

Members are cordially invited to attend. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

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Spaceflight

The International Magazine of Space and Astronautics

Moon Programme for Europe?

Shuttle's Radar Mission

Latest Space News and Launches

Spacewalk in Noordwijk

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Spaceflight

The International Magazine of Space and Astronautics

Published By The British Interplanetary Society

Vol. 36 No. 8 August 1994

Space Education

Soviet Policy & Technology

Features

News & Events

Space Miscellany

Front Cover: **A scene at the Noordwijk Space Expo, which is the largest permanent space exhibition in Europe and also functions as the official Visitor's Centre for ESTEC, the technical centre of ESA.**
ESA

Moon Added to Euro Space Agenda

International Programme to Start with 21st Century

The ESA Moon Initiative began in 1990 with a study of the scientific possibilities offered by a Moon programme. The initiative has now moved on to focus on broader issues, such as the technological requirements, the means of transportation, the infrastructure (energy, telecommunications etc.) and the eventual role that man might play.

Ways to preserve what is a unique environment for scientific studies and the possibilities of international cooperation in a Moon programme are being looked into and were discussed at the recent International Lunar Workshop in Switzerland which is reported on the opposite page.

In 1995 the ESA initiative will be discussed at the Ministerial Conference, and if the proposal is selected, the launch of the first European lunar orbiter could be envisaged for about the year 2003.

In the words of Roger Bonnet, Director of ESA's scientific programme:

The study being conducted at ESA is one of both realism and vision. Between the International Space Station and the human exploration of Mars, the Lunar programme has a logical place. The international programme that we Europeans hope to develop at the very beginning of the next century, will join together, from the year 2000 onwards, all the nations of the world in a 'lunar quinquennium' which will mark the start of a new phase in space exploration for the next century'.

ESA recognises that the question of space activities is frequently raised today in the context of the current poor economic climate and the high costs they entail. It also recognises that in order to persuade governments to invest money in a Moon initiative, convincing arguments have to be put forward.

ESA sees and will stress the benefits of such a programme: technological progress, boosting of the economy and employment engendered in technological progress, increased scientific knowledge, exploitation of the Moon's resources, and fostering of international cooperation. A Moon initiative is also seen as a stimulus for scientific education and as a natural testbed for a future mission to Mars.

According to Roger Bonnet:

The new Moon programme will follow a phased approach starting with the initial exploration using small satellites and surface probes, progressing to the use of robots for scientific and resource exploitation, and culminating in manned lunar bases.

Sergio Volonté, ESA's astronomy mission coordinator, explains further:

The programme phases will be tailored to the budget availabilities, in which the missions of the far future will benefit from the knowledge and experience gained during the initial phases, shaping the programme to the resources of the participating nations and to optimise its return.

In initiating a Moon programme it is important for ESA to be able to propose a possible first step. A step that can be carried out with European means only - both technologically and financially. It is for this reason that, despite the fact that the Moon programme is an international endeavour, ESA is already looking at missions which could be implemented in the first stage in a purely European context.

Four main phases have been identified by ESA:

Lunar Resource Explorers

This phase will involve the use of orbiters and/or landers to perform a systematic exploration of the Moon's resources: ESA is presently studying two technological mission concepts for this use. The preferred concept concerns a lander and a rover. The other concerns an orbiter with a tethered satellite.

As part of the ESA Science Programme a lunar orbiter mission (MORO) is also being considered. Unlike the technological missions, where emphasis will be on demonstrating new technologies and capabilities, this lunar orbiter mission will use already existing technologies and its function will be purely scientific.

Permanent Robotic Presence

This phase concerns telepresence, remote chemical analysis, geophysical observation and survey, assessment of the environment, installation of a pilot radio astronomy instrument, and resource exploration. It is hoped that by the time a Moon mission takes place, man-machine interface concepts will have developed to such an extent that an operator on Earth will have as much control in picking up and examining samples and selecting important specimens for examination as he would have if he were present on the lunar surface.

First Use of Lunar Resources and Environment

The use of lunar resources on site, particularly oxygen, will be implemented during the third phase. Construction techniques will be investigated, the first biological experiments will take place and Very Low Frequency Astronomy (VLFA) will begin.

The First Human Outpost

The development of a manned lunar base, the ultimate aim of the programme, will take place during the final phase. A scientific laboratory and a sub-mm interferometer will be installed, geological investigations will continue, and the technology for the production of lunar oxygen will be exploited. ■

The Role of Ariane-5

In its present configuration, Ariane-5 can deliver both lunar orbiters and lunar landers. Two possibilities for early lunar missions are dedicated Ariane-5 launches and 50:50 shared launches.

A dedicated Ariane-5 launch can put about 4450 kg of payload into a Lunar Transfer Orbit (LTO) and the timing of the launch can be optimised for that particular mission. The optimisation gains are comparatively small, however, so that practically speaking a dedicated lunar launch can take place at any time of year. The transfer time to low lunar orbit would be about 5 days, but this could be reduced to 2 days with a relatively modest fuel supplement of 140 kg. For a mission involving a lander, some 800 kg of payload could be landed softly on the Moon's surface.

The second possibility is a shared launch into Geostationary Transfer Orbit (GTO), but there are several operational constraints. Customers for GTO orbits generally have a specific requirement in terms of the direction of the Sun at orbit apogee, which dictates a specific launch time each day. The plane of the Moon does not necessarily coincide with this Sun direction. In practice, the velocity increment required for lunar transfer from GTO is a minimum for just two launch windows per year, with extra fuel needed for other launch dates. The transfer time would also be much longer, ranging from 40 to 60 days, depending on the position of the Moon at launch. For a 50:50 shared launch, 2870 kg of payload would be available in GTO, which can still support a significant lunar mission, such as a 400 kg orbiter combined with a lander carrying a 200 kg payload.

Ariane-5 can fully support the proposed 'first phase'. The transportation requirements for the 'second and third phases' can also be met using an upgraded version of Ariane-5. For the 'fourth phase', a new class of launcher with an even greater lift capability would probably need to be developed. ■

International Lunar Workshop

Beatenberg, Switzerland 31 May - 3 June 1994

One kilometre above Lake Thun in Switzerland, some 140 scientists and engineers from Europe, America, Japan and Russia came together in the first week of June to discuss the possibility of a return to the Moon some 25 years after the Apollo 11 mission. The meeting was organised by Switzerland and the European Space Agency, and had a keynote address by Sir Hermann Bondi of Churchill College, Cambridge, one time Director General of ESRO - ESA's predecessor organisation.

BY BOB PARKINSON
BIS Council Member and Chairman of the International Lunar Workshop Working Group 5

The workshop covered scientific, political and legal issues associated with lunar exploration and exploitation. Possible sites, environmental issues and the means of resuming lunar activities in the form of transportation and surface infrastructure were also covered.

Science

Possible scientific objectives of a return to the Moon were described under the headings of "Science of the Moon", "Science on the Moon" and "Science from the Moon".

Science of the Moon would extend the geological understanding started with Apollo and recently added to by Clementine to illuminate the history of the Earth-Moon system, which represents a unique "binary planet" within the Solar System. The results of the Clementine mission were presented during the Workshop.

"Science on the Moon" would perhaps only come about with the return of human beings to the Moon, and would study the adaptation of people to the lunar environment.

"Science from the Moon" would involve exploitation of the special qualities of the Moon as a base for astronomy. The almost total absence of seismic activity on the Moon makes it an ideal site for multiple astronomical instruments, and the complete shielding of the far side of the Moon from man-made electromagnetic interference makes it ideally suited to high sensitivity radio astronomy.

Phased Programme

The programme being proposed by ESA would have four stages, with each stage not only performing valuable science but also developing the technology and capabilities for the following phase. Phase 1 would involve sending a robot orbiter/lander to the Moon, possibly carrying one or more small rovers to investigate a local area such as the lunar south pole, not previously surveyed by Apollo.

In the second phase, a permanent teleoperated robotic presence might be placed on the Moon, and more complex instruments could be installed and deployed - allowing the foundation of lunar astronomy.

In the second or third phases farside operations might be begun also. The third phase would focus on the first experimental exploitation of lunar resources including the extraction of oxygen from moonrock. Only after all of this, and when the case had been clearly established for a human presence, would human beings return to the Moon.

One advantage of this phased approach was that the first stage could begin at once, and no new transportation system (beyond Ariane 5) would be required until Phase 4 was reached. By this time, new economic transportation systems may have been developed for other purposes, making human operations less expensive.

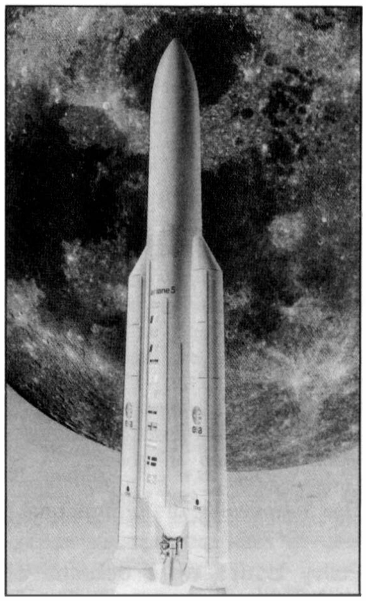
Liquid Oxygen Production

The use of lunar liquid oxygen would approximately halve the launch mass required to return human beings from the Moon. NASA Johnson described experiments already carried out using hydrogen reduction of iron oxide in moonrock to recover about 6% by weight of oxygen. Other experiments using a higher temperature methane reduction indicate the possibility of recovering about 25% by weight of oxygen from moonrock, and also producing iron and silicon as byproducts. It is entirely possible that a lunar liquid oxygen plant could be landed in advance of the first human return to supply the return propellant required.

Tele-Presence

A major theme of the conference was the use of teleoperation and robotics to support activities on the Moon. The time delay of 3 seconds between an operator on Earth and feedback from a machine on the Moon is no longer a problem, thanks to "virtual reality" interfaces and "artificial intelligence" predictions to indicate where the machine will be.

A recent test by NASA, McDonnell Douglas, the Planetary Society and the Russian Space Agency demonstrated teleoperation of the Russian "Marsokhod" rover at Amboy Crater in California using not only robotic experts and geologists to control it, but also members of a schoolteachers' conference where the system was demonstrated.



Europe could take the initiative by completing work on the 'Lunar European Demonstration Approach (LEDA)' mission which could be launched close to the turn of the century, relying on a shared Ariane-5 launch to keep costs low. Concepts being considered for the mission include a robotic payload as a lunar lander. ESA

There was vigorous discussion at a "Round Table" on 2 June on the relative advantages of humans "on site" and teleoperated robots by a panel which included both astronauts and robotic experts.

Environmental Protection

The problems of protecting the lunar environment were also discussed. The lunar surface contains detailed evidence of its past history not available on Earth, and the farside provides the only "electromagnetically clean" area in the Solar System accessible to us.

Fortunately the Moon appears to be a reasonably forgiving environment and, at least for the moment, the environment can be protected with only a little care. Communications on the lunar farside, for example, may have to be limited to the laser communications systems already being developed for intersatellite links.

International Cooperation

Similar phased programmes to that being proposed by ESA were also being considered in Japan and as possibilities in the US. The workshop advocated steadily developing international co-ordination and collaboration to make the most effective use of available programmes.

International Lunar Workshop (Continued)

Beatenberg, Switzerland 31 May - 3 June 1994

Working Group reports and a dozen individually contributed papers were presented at the Meeting. The seven Working Groups reported on:

- Current plans for lunar activities of various organisations;
- Transportation capabilities;
- Political and economic issues of a return to the Moon;
- Protection of, and from, the lunar environment;
- Infrastructure (energy, telecommunications etc.) both before and after the Moon becomes inhabited;
- Lunar sites;
- The framework of international lunar collaboration.

Policy issues were debated at two Round Table discussions. The Round Table discussion on 'Tradeoffs between robotic, man-tended and permanently manned exploration and exploitation was held under the chairmanship of ESA astronaut Claude Nicollier. The second Round Table on 'A Strategy for the Future?' was chaired by H. Curien, Université de Paris VI and J. Geiss, University of Bonn who are Co-Chairmen of the International Programme Committee.

At the end of the Meeting the following Declaration was issued.

DECLARATION

On the initiative of Switzerland and the European Space Agency, representatives from space agencies, scientific institutions and industry from around the world met in Beatenberg, Switzerland from 31 May to 3 June 1994 to consider plans for the implementation of internationally coordinated programmes for robotic and human Lunar Exploration.

The meeting was enthusiastic about the rich opportunities offered by the exploration and utilisation of the Moon.

- The uniqueness of the Earth-Moon system was emphasised and the potential of the Moon as a natural long-term space-station was recognised.

- The Workshop agreed that the time is right, scientifically and technologically, for a staged lunar programme implemented in evolutionary phases, the first phase involving science, technology, and resource exploration missions. The initial phases of the programme, involving Moon orbiters and landers with roving robots, are within the capabilities of the various individual space agencies technically and financially; but the benefits, scientifically and technologically, would be greatly enhanced by close coordination. Each phase should set the task for the next one, but will be fully justified on its own merits without being in any way dependent on the follow-on.

- Strong interest was expressed in the science of the Moon (illuminating the history of the Earth-Moon system), from the Moon (for astronomical projects), and on the Moon (biological reactions to low gravity and the unique radiation environment).

- The phased evolutionary approach allows the differences of opinion over the role of humans in space and the economic utilisation of the Moon to be assessed later in the light of results from earlier phases. As the programme progresses, it is possible that the attractions and benefits of human presence on the Moon will become clearly apparent. It is evident, however, that the Moon would represent the next logical step and a testbed in any plans of human expansion into the solar system.

- The Workshop concluded that existing launcher systems would permit the implementation of the initial phases. The significant technological advances required in areas such as robotics, telepresence, and teleoperations will certainly find scientific and industrial applications on Earth.

- The Workshop agreed that the objectives of the programme can be accomplished while at the same time protecting the lunar environment.

- The Workshop concluded that current international space treaties provide a constructive legal regime within which to conduct peaceful scientific exploration and economic utilisation of the Moon, including the establishment of permanent scientific bases and observatories.

In conclusion the Workshop agreed that this is the right time:

- to begin the first phase of the lunar programme;
- to prepare for future decisions on later phases;
- to implement international coordination and cooperation;
- to establish, at a working level, a mechanism for regular coordination of activities.

A second International Lunar Workshop will be held in mid-1996 to review progress and plans. ■

A Moon Programme: The Next Step?

As well as the scientific and technical considerations of a return to the Moon, ESA faces the problem of arguing and 'selling' a Moon programme on a broad political front and in a current economic climate that is heavily preoccupied with many pressing Earthbound considerations. Where, then, does the Moon fit in - and with realism and vision? ESA puts forward the European viewpoint in a recently published brochure* from which the following is an extract:

Today, the need for long-term and ambitious programmes is more important than ever. Large programmes are necessary to stimulate global economic development, not this time through technology 'outbursts' of the type induced by the World Wars of the 20th Century, but through purely peaceful, civilian initiatives that would give a new meaning to the word 'work' and would provide a means of occupying everyone's talents for the common good and to the benefit of future civilisation, namely our children.

Space programmes represent one such initiative, one that encompasses science and high-technology activities on a planetary scale, serving mankind, helping it to communicate, and offering a 'mirror' with which to survey our home planet, whilst at the same time exploring the Universe and its eventual habitability.

Currently, the major space nations are directly involved in or associated with the development of an international space station, which is today's largest international space programme. The next international space programmes will see the continuation of space science, Earth observation and space applications, leading eventually to the exploration and exploitation of the Moon, and to the setting up of manned outposts first on the Moon, and later on Mars, sometime during the 21st Century. The Moon therefore constitutes a logical next step.

It is important that Europe continues to play an important and rewarding role in such future programmes and it is well equipped to do so. Over the years, Europe has developed the critical space capabilities needed for lunar missions: these include the Ariane-5 launch vehicle, lander engines, sophisticated communications systems, sensors, etc. Europe also has a large pool of talented scientists, engineers and industrialists who have a strong interest in studying and using the Moon.

An enterprising Moon Programme can serve to accelerate the successes of European space activities in many sectors. It would represent a long-term investment in a high-technology international programme that would tax the skills and ingenuity of the scientific and industrial participants, pushing them to the frontiers of knowledge and know-how, leading to new discoveries and innovations, new and better products, and improvements in industrial processes and methodologies. The end result would be greater competitiveness and the creation of new markets, new jobs, and new sources of income.

The Moon is already a part of our 'environment' and should be accessible to all, not just those privileged to be chosen as astronauts. Via the sophistication of telepresence and virtual reality, the proposed Moon Programme can 'involve' everybody on Earth, whatever their chosen technical profession. It would be an incentive for the younger generations to develop their best talents in exploiting this new and as-yet virgin territory. ■

** B. Battrick (ed), 'A Moon Programme: The European View', ESA BR-101, Prepared by Wubbo J. Ockels, ESA Publication Division, May 1994.*

DC-X Tests Resume

On 20 June the single-stage DC-X vehicle lifted off at 8:42 am MDT to begin its fourth consecutive flight to demonstrate vertical takeoff and landing and subsonic manoeuvrability.

The DC-X reached an altitude of 1,500 feet, and then followed a curved ascent to a height of 2,600 feet, travelling laterally 1,050 feet from the take-off point.

Then flight controls commanded the DC-X to reverse its direction of flight and climb to an altitude of 2,850 feet. Once over its landing pad the vehicle descended vertically and touched down 136 seconds after liftoff. During this flight profile, the vehicle went through an angle-of-attack range from zero to 70 degrees.

At engine startup on the next test on 27 June, an explosion of unknown origin took place with subsequent damage to the DC-X's graphite fibre aeroshell. Liftoff was according to expectations and, at 17 seconds into the initial launch and flight mode, the DC-X flight manager initiated the vehicle's emergency autoland sequence. It descended according to plan and returned essentially intact so that it can be repaired and flown again. Total flight time from start of engines to landing was 78 seconds.

After completion of the planned flight test series this summer, the DC-X will be turned over to NASA, who is planning to upgrade systems and subsystems and incorporate advanced technologies for reflight of the vehicle in 1996.

First Pegasus XL Launch Fails

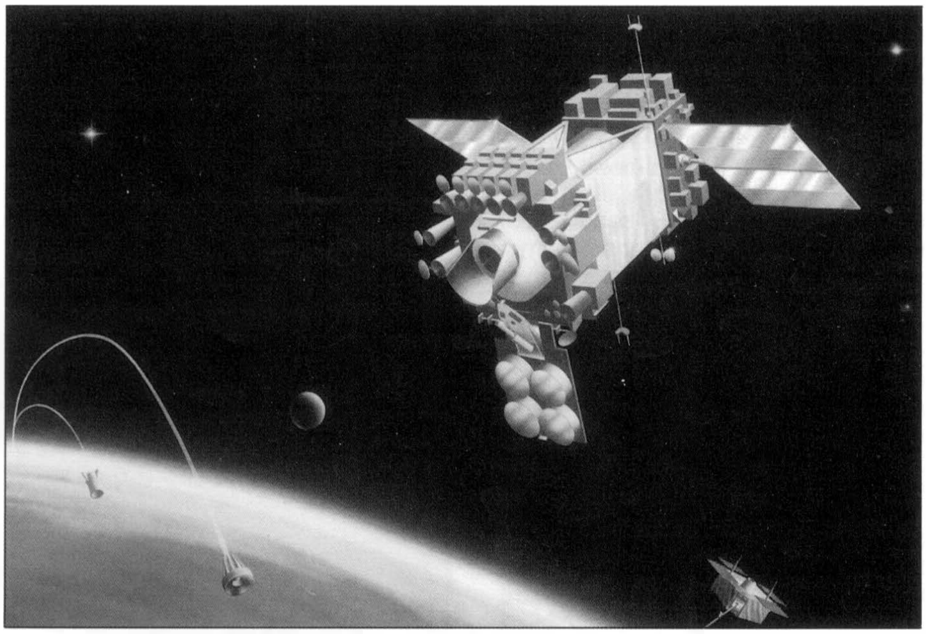
The first Pegasus XL was destroyed by ground control during launch on June 27. It was intended to carry the US Air Force STEP Mission 1 satellite into orbit.

The Lockheed L-1011 Stargazer carrier aircraft had taken off from Vandenberg AFB and had flown out to the launch point. The launch was made at 2:15 pm PDT off the California coast. The drop and first stage ignition were normal, but 35 seconds into the burn, ground control noticed a problem. At about 2 minutes and 50 seconds into the flight the destruct signal was transmitted. The Pegasus XL was about 240 miles off the coast and was at an altitude of 124,000 feet.

A Failure Investigation Review Board was established to find the cause of the failure and recommend modifications. The launch of the Pegasus XL was to start an ambitious launch schedule for 1994, with another six launches originally planned for the rest of the year. These will now be delayed until the Board's investigation is completed and the modifications made.

This was the first Pegasus air-launched booster to fail. In addition to orbiting the STEP Mission 1 satellite, the launch was also to be the first to use the new L-1011 carrier aircraft. All previous launches had used NASA's NB-52.

CURTIS PEEBLES



Artist's conception of MSX observatory in orbit. MSX is capable of observations at a wide range of ultraviolet, visible and infrared wavelengths from 110 nm to 28μm. APL

MSX Spacecraft Readied for Launch

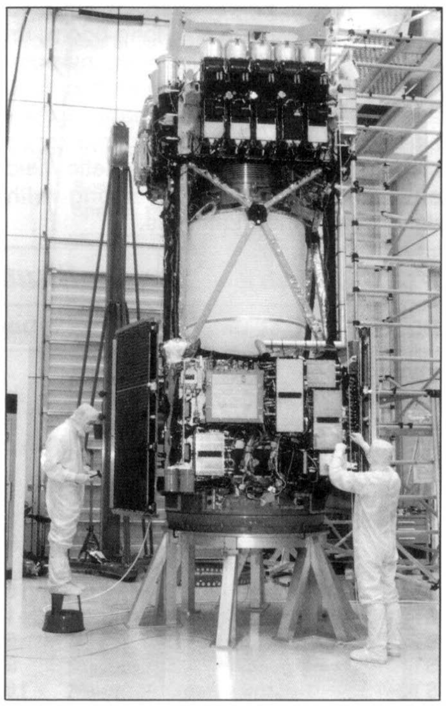
The Midcourse Space Experiment (MSX) is a Ballistic Missile Defense Organization (BMDO) mission to support research on the space-based tracking of ballistic missiles. It will also perform a wide variety of research involving global change, astronomy, and space debris.

MSX will be the first system demonstration in space of technology to characterise ballistic missile signatures during midcourse flight, i.e. the trajectory phase between booster burnout and missile reentry. The satellite is designed to detect, track and discriminate realistic targets against terrestrial, Earth limb, and celestial backgrounds. To do this the satellite has advanced capabilities which offer the scientific opportunity for environmental monitoring through simultaneous observations of atmospheric gases such as ozone, chlorofluorocarbons, carbon dioxide, and methane. It will provide data on global climate change and ozone depletion in the period before NASA launches its EOS (Earth Observing System) satellites. MSX will also provide unique data on far-infrared and ultraviolet astronomy and will measure the population of small space debris, which is of particular concern to manned space flight.

APL, a division of The Johns Hopkins University, is under contract to BMDO to build, launch, and operate the MSX satellite and several primary sensors during its five-year lifetime. On 22 June, the spacecraft was transported from APL in Laurel, Md., to NASA's Goddard Space Flight Center in Greenbelt, Md., for environmental testing and preliminary launch preparation where it is expected to spend three months prior to liftoff in November aboard a Delta II booster from Vandenberg Air Force Base in California. Mission altitude is approximately 900 km, in a high-inclination, circular, near sun-synchronous Earth orbit. Operations will be conducted from a mission control centre on the APL campus.

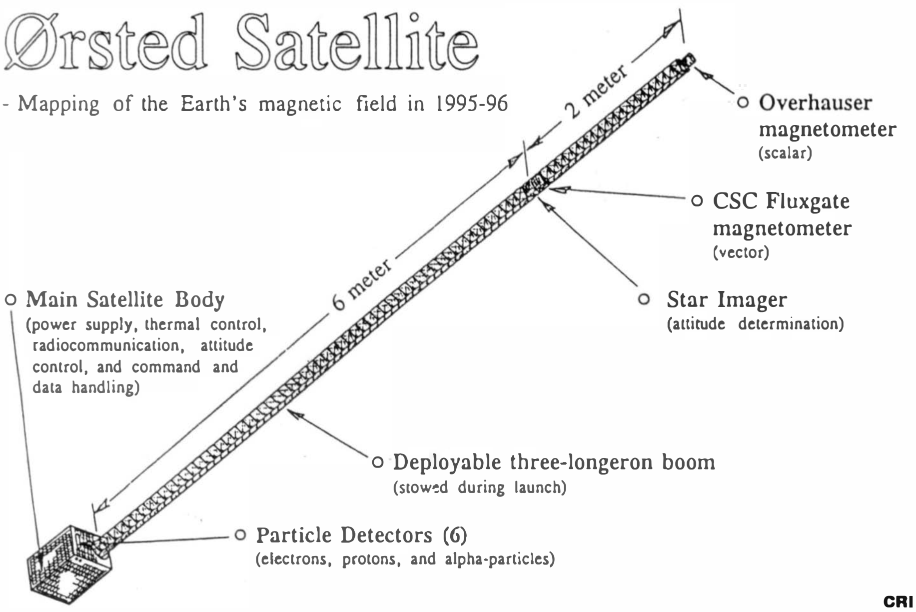
The MSX programme is supported by about 100 scientists from 30 institutions.

The BMDO-sponsored Midcourse Space Experiment (MSX) undergoes final preparation at The Johns Hopkins University Applied Physics Laboratory before its move on June 22 to the Goddard Space Flight Center for environmental testing. MSX is scheduled for launch in November 1994 from Vandenberg Air Force Base.
THE APPLIED PHYSICS LABORATORY, LAUREL, MD



Ørsted Satellite

- Mapping of the Earth's magnetic field in 1995-96



CRI

Denmark's First Satellite

The idea of the Oersted satellite was initiated as a cooperative effort between Danish research institutions and space-related industry. Encouragement was provided by the successful launch and operation of several small microsatellites in the 10-50 kg range by such organisations as the Amateur Radio Satellite Corporation, the University of Surrey and the University of Berlin. Launch is scheduled for late 1995 or early 1996.

Other factors leading to the project were:

- the technological advances now being made in microelectronics towards smaller and cheaper components with increased power efficiency and reliability and;
- the availability of low-cost launch opportunities as a secondary payload on the Ariane Structure for Auxiliary Payloads (ASAP) and other large launch vehicles, such as the Delta-II.

Oersted Satellite

The satellite is box shaped, 34 cm x 45 cm x 68 cm, with an 8 m long boom. Its total weight is 60kg. Its main purpose is to map the Earth's magnetic field and to measure charged particle densities for the purpose of improving models of the Earth's magnetic field and auroral phenomena along with data from other satellites.

The orbit will be a sun-synchronous polar orbit, 400km x 800km, and the launch, which is to be provided free by the USA on a Delta-II rocket, will take place from Vandenberg AFB in late 1995 or early 1996. The satellite is expected to have a lifetime of one year.

Power is supplied by five solar panels and batteries. At least 12 hr of scientific data can be stored and is transmitted at a maximum data rate of 256 kbit/sec 2-3 times per day over Denmark. Stabilisation is by gravity gradient with the 8m long boom. Attitude is automatically corrected by means of electromagnetic field coils and is controlled with high accuracy by means of the CSC fluxgate magnetometer (see below), a multi-channel GPS receiver (giving an accuracy of better than 50 m) and sunsensors.

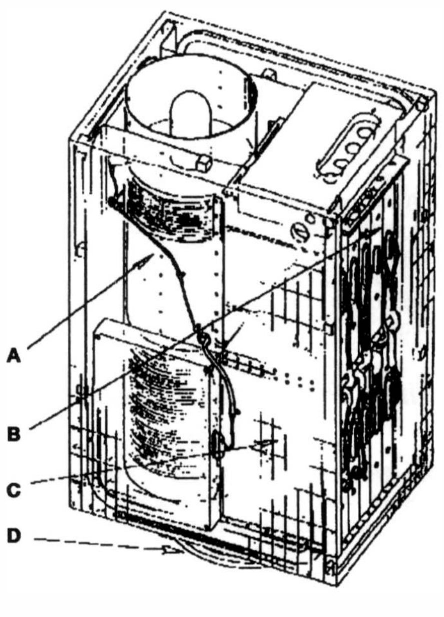
Instruments

Four scientific instruments are carried:

- Overhauser proton-precession magnetometer for measurement of the magnetic scalar field with an accuracy of less than 1 nT (nanotesla);
- CSC fluxgate magnetometer for measurement of the magnetic vector field with an accuracy of less than 3-5 nT;
- Particle detector for the measurement of electrons (30 kev - 1 Mev), protons (200 kev - 30 Mev) and alpha particles (1 - 100 Mev);
- Star camera to pinpoint the direction for the CSC fluxgate magnetometer with an accuracy of less than 20 arcseconds.

Ground Segment

The Control Centre is at CRI, Computer Resources International, Copenhagen where the satellite will be assembled. The Data Centre is at DMI, Denmark's Meteorological Institute, Copenhagen. **J.K. ANDERSEN**



Oersted is a mini satellite of 60 kg mass with dimensions 34 cm x 45 cm x 68 cm, data storage of 16 Mbytes (13 hr data) and an average power concumption of 26 W. Key:

A Boom with science instruments (stowed during launch)
B Electronic boxes
C Solar panels (5 sides)
D Separations mechanism

CRI

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
1994					
STS-68	Mid-August	Endeavour	9 Days	SRL-2	57.0
STS-64	September	Discovery	9 Days	LITE, GBA	57.0
STS-66	Late October	Atlantis	10 Days	Atlas-3, Crista-SPAS, SSBUV/A	57.0
1995					
STS-67	January	Endeavour	13 Days	ASTRO-2	28.5
STS-63	February	Discovery	8 Days	Spacehab-3, Spartan-204, CGP/Oderacs-2	51.6
STS-69	May	Endeavour	10 Days	Spartan, WSF	28.5
STS-71	May	Atlantis	9+1 Days	Mir-01 Mission	51.6
STS-70	July	Discovery	5 Days	TDRS-G	28.5
STS-72	September	Endeavour	9 Days	Spartan, SSBUVA	28.5
STS-73	September	Columbia	16 Days	USML-02	28.5

Floating Launch Pad

Plans to launch commercial satellites from a floating launch pad at the equator are being pursued by an international partnership that includes Norway's Kvaerner group. Other members of the consortium are the US Boeing group, the Russian space company NPO-Energiya and the Ukrainian rocket manufacturer NPO-Yuzhnoye.

Kvaerner will be responsible for developing, completing and operating the ocean-going launch pad, which is conceived as a semi-submersible unit. The group has built up expertise in this area through its Kvaerner Shipbuilding and Kvaerner Oil and Gas business areas.

Ariane Launches Resume

Asia-Pacific Coverage Implemented

Within a period of three weeks, Arianespace has successfully launched two Ariane rockets, Flights 64 and 65, and re-established its launch schedule following the delay resulting from the failure of Flight 63 on 24 January.

On 9 July, an Ariane 44L, the most powerful version of the European launcher, equipped with four liquid-propellant strap-on boosters was launched from the Space Centre in Kourou, French Guiana at 8:05 pm on 8 July (local time).

Two satellites were orbited: PAS-2, the first new-generation satellite for the American company PanAmSat, and BS-3N, a Japanese direct TV broadcast satellite for the Nippon Hoso Kyokai (NHK) network and Japan Satellite Broadcasting (JSB). PAS-2 will cover the Asia-Pacific region from a position over the Marshall Islands and BS-3N will broadcast TV programmes to all of Japan from a position above the island of Borneo.

UK Microsatellites Orbited

On 17 June, Arianespace successfully launched the Intelsat 702 satellite, the second in this new-generation series operated by Intelsat. Two UK-built microsatellites were also put into orbit to become the first complete UK satellite programme since 1971.

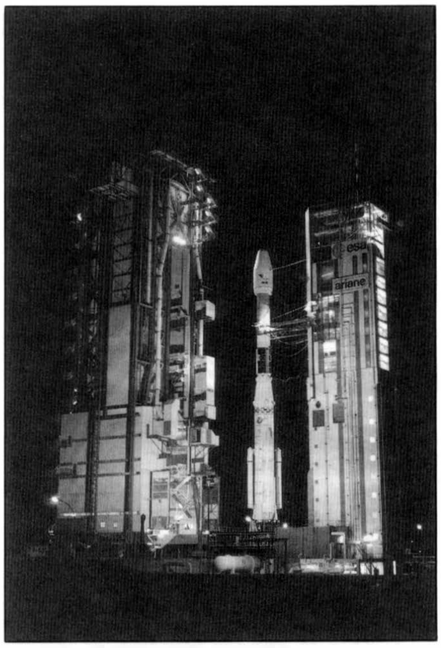
The launch vehicle for Flight 64 was an Ariane 44LP, the version equipped with two liquid-propellant and two solid-propellant strap-on boosters.

Intelsat 702 was built by Space Systems/LORAL in Palo Alto, California. Weighing 3,695 kg at liftoff, it is equipped with 26 C-band transponders and 10 Ku-band transponders. It will provide international telephony links, television programme transmission and video transmissions for the Atlantic region being deployed at 359 °E longitude.

Flight 64 also placed two microsatellites, STRV (Space Technology Research Vehicles) 1A and 1B, into geostationary transfer orbit for the British Ministry of Defence. Built by the UK Defence Research Agency as prime contractor, these satellites are designed to investigate the effects of the space environment on electronics and structures of satellites; and to demonstrate a range of future spacecraft technologies.

Environmental effects shorten the operational life of satellites and can lead to the complete loss of spacecraft if the control electronics is critically damaged. To maximise their exposure to these effects, the STRV satellites were placed in a highly elliptical orbit at a height which varies from 300 km to 36000 km. This carries them through the Earth's radiation belts four times a day and exposes them to the effects of the atomic oxygen at low altitudes. In their expected life of one year, they will receive a radiation dose equivalent to 10 times that in geostationary orbit.

The satellites were designed at DRA (the UK Defence Research Agency) and were assembled and tested in the agency's space test facility at Farnborough. They will be controlled and monitored from DRA's ground station at Lasham. The NASA facility at Goldstone in the US will act as a secondary ground station. This is DRA's first complete satellite programme since the launch of the Prospero research satellite on the UK Black Arrow vehicle in 1971.



Ariane 44 LP with two liquid and two solid strap-on boosters being prepared for lift-off of Flight 64. ARIANESPACE

Columbia's Two-Week Mission

Despite earlier concerns about storms, both at KSC and at the shuttle emergency landing sites in West Africa, the weather cooperated and Columbia, NASA's oldest shuttle, began its 17th mission, STS-65, at 12:43 pm EDT, right on time.

Japan's first woman astronaut, Chiaki Mukai, 42, a heart surgeon from Tokyo, and six American crewmates were aboard the shuttle which carried the International Microgravity Laboratory-2 (IML-2) payload, a major part of the scientific investigations and hardware of which had been provided by the European Space Agency (ESA). The mission agenda involves the crew in forging new high-tech materials, cultivating protein crystals for drug research, studying the reproductive cycles of fish and amphibians, and conducting medical tests on themselves. Once in orbit, the seven astronauts split into two teams to work on 82 experiments from 13 countries. NASA associate administrator Harry Holloway called the mission "a door opener" to a future international space station.

Atlas Success

On 24 June, Martin Marietta launched its first Atlas rocket from Cape Canaveral Air Station less than two months after a $208 million takeover of the booster's original maker, General Dynamics.

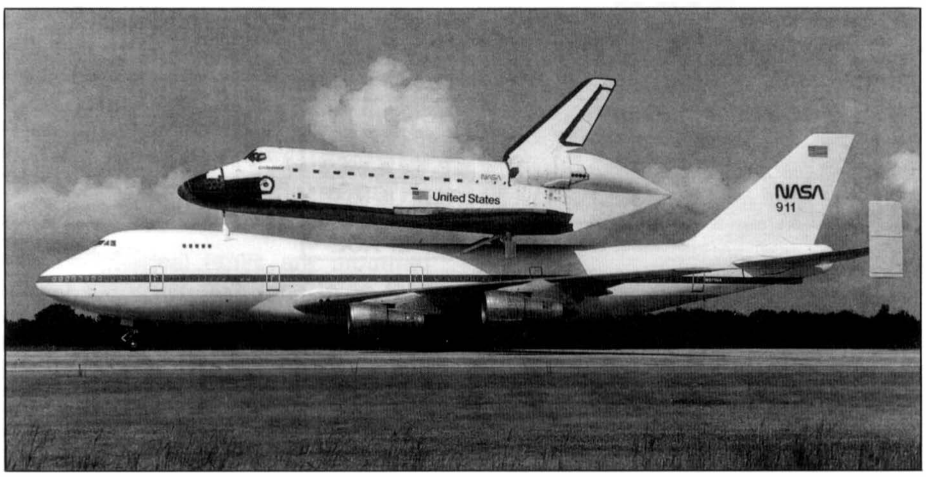
It was the second successful Atlas launch this year, the 514th Atlas launch overall and the 82nd flight for Atlas with Centaur. The launch was the third in a series of nine in the US Navy UHF Follow-on programme. UHF Follow-on satellites are replacing the Fleet Satellite Communications and Leasat spacecraft presently supporting the Navy's communications network.

Ulysses at the Sun

Ulysses became the first spacecraft in history to reach a polar region of the Sun when it passed over the Sun's southern polar area on 26 June after a journey of almost four years from Earth. Ulysses was deployed from the Space Shuttle Discovery in October 1990. In February 1992, it spent nearly 11 days exploring unknown regions of Jupiter before gaining enough momentum to loop out of the ecliptic and on to an orbit that passes over the poles of the Sun. It now begins a four-month study of the solar polar regions.

Endeavour finally returns to KSC's Shuttle Landing Facility on 2 May some 12 days after landing at Edwards AFB, California at the end of mission STS-59.

Endeavour's next mission is STS-68 to be launched in mid-August with Space Radar Laboratory 2 as payload. The mission will repeat the observations of STS-59 in order to study seasonal ground changes. PETER GUALTIERI, WEST KENTUCKY NEWS



Popular Space Support

In a recent poll commissioned by Rockwell an increasing percentage of Americans were shown to support the US space station.

Conducted in late May, the survey revealed that 68% favour NASA's goal to construct a manned space station; this was up five percent on the previous year. The majority think that building the space station jointly with Russia or other countries is a good idea, and 73% say the US should "initiate joint space missions with other countries".

An overwhelming majority (84%) support continued US space exploration despite the demise of the Cold War, and 72% said they approve of the current civilian space programme.

America's space programme is "worth the cost", said two thirds of those polled, and support for spending "whatever is necessary to maintain US leadership in space" remains at record high levels (62%).

More than 80% believe the US space programme is good for the country and that the "discoveries made in space can help on Earth".

Americans view the possibility of making "new and important scientific and medical discoveries" as an important benefit of the programme.

Other benefits include increasing the understanding of the Earth's weather, climate and environment (81%) and "developing new technologies which improve productivity and help keep America economically competitive in the world" (70%). A slightly larger group (84%) also noted the value of using space satellites as a means of monitoring the Earth's environment. An extraordinarily high percentage of those polled (90%) recognise the educational value of space.

A majority (55%) support expansion of the space programme and fewer than half (46%) would like to see expenditures cut back compared to 51% in 1993. The poll had a margin of error of plus or minus three percent.

Hughes Award

The US government has been ordered to pay Hughes Aircraft $114 million for repeatedly infringing on a pioneering communications satellite patent over a span of two decades. The dispute involves the invention in 1959 by scientist Donald Williams of a satellite attitude control system that proved to be the solution to a problem that had stymied government and private industry scientists. Williams applied for a patent in April 1960, and that invention, characterised by NASA at the time as a "unique" and "important patent", made the geosynchronous satellite practical and ushered in the age of global satellite communications.

Hughes filed its lawsuit in 1973 and had attempted to settle. The lawsuit is one of the longest running patent infringement cases against the US Government. The ruling is subject to appeal.

UN to Hold Space Conference

The UN Committee on the Peaceful Use of Space (COPOUS) has decided that a third UN space conference would benefit developing countries but has yet to agree on the date and venue. It is expected to take place in 1996 and the space centre in the southern Indian state of Bangalore is a possible venue.

The last UNISPACE gathering was held in 1982 - 14 years after the first was convened. A COPOUS report says that the new, generally cooperative and non-belligerent tone that currently characterizes international relations should increase the likelihood that a third UNISPACE conference would be more meaningful than the second which was constrained by the Cold War tensions of the time.

Canada's Space Plan

Canada's continued participation in the International Space Station with a reduced overall financial commitment will not be without some pain, according to Mr Mackay Senior Vice-President of Spar Space Systems. Nevertheless the decision ensures that Canada will remain a world leader in space-based robotics and that the Canadian Space Agency will remain a full partner in the International Space Station with Canada retaining responsibility for the design and development of the robotics that will be used to build, service and maintain the space station. Under Canada's Long Term Space Plan a subsequent generation of the Radarsat programme will help solidify Canada's leadership position in the remote sensing, information and data business.

Radarsat 3 Project

The high success of the data transmitted by the microwave sensors of ERS-1, especially by its Synthetic Aperture Radar (SAR), is helping to push ahead a SPOT Image project for a radar satellite. Radarsat 3 is the name of this joint project between CNES and SPOT Image in France and the Canadian Space Agency and Radarsat International in Canada. Preliminary studies concerning the type of frequencies for radar remote sensing and the requirements of the customers for all-weather observations of the Earth are in progress. Their main purpose is to find a system that would be complementary to the Synthetic Aperture Radar of the ERS system of ESA. It is planned to launch Radarsat 3 in the year 2000.

Germany and Italy are also working on radar systems for Earth observations in cooperation with NASA and the Jet Propulsion Laboratory. The flight of Endeavour on mission STS-59 carried the remote sensing payload, Space Radar Laboratory-1 into orbit. This consisted of an American SIR in C-band and a German-Italian SAR in X-band which permit parallel measurement in a frequency range of 3 cm (X-band), 5 cm (C-band) and 20 cm (L-band).

THEO PIRARD

Kyrgyz Republic Joins Intelsat

The Kyrgyz Republic has joined Intelsat as its 133rd member nation with an initial investment share of 0.05 percent. Krygyz Telecom is the Republic's newly organised long distance carrier. Intelsat owns and operates the world's most extensive global communications satellite system.

Bahamas Joins Inmarsat

The Bahamas has become the first Caribbean Community country to join Inmarsat, bringing the total number of member nations to 74.

Space Station Interim Agreement

On 23 June, NASA and the Russian Space Agency (RSA) signed two significant documents which put the United States and Russian space cooperation on a firm basis and underpin Russian participation in the International Space Station programme.

NASA and RSA signed an "Interim Agreement for the Conduct of Activities Leading to Russian Partnership in Permanently Manned Civil Space Station" that provides for initial Russian participation in the International Space Station programme. The Interim Agreement will govern Russian participation until an Intergovernmental Agreement (IGA) and a NASA-RSA Memorandum of Understanding can be concluded.

NASA and RSA also signed a separate $400 million contract for Russian space hardware, services and data. Under this contract, NASA will purchase hardware and services from RSA and its subcontractors for approximately $100 million per year over four years in support of a joint programme involving the Space Shuttle and the Mir space station. The contract also covers early International Space Station activities.

The Interim Agreement establishes bilateral management mechanisms which are fully consistent with existing management mechanisms utilised by the International Space Station partners. It also provides for Russian participation in the existing multinational Space Station management mechanisms.

The agreement establishes, among other things, a NASA/RSA Programme Coordination Committee which will review design and development activities during his initial cooperation. It also provides for RSA's participation on the Space Station Control Board, along with the other partners, which controls the Space Station requirements, configuration and interfaces up to the completion of assembly and initial operational verification. RSA will also be included in the Multilateral Coordination Board which ensures coordination of the operation and utilisation activities of the Space Station.

The agreement provides for the establishment of Space Station technical liaison offices in Moscow and Houston for purposes of facilitating the working relationships between NASA and RSA.

Multilateral negotiations involving Russia and other Space Station partners on a protocol amending the Space Station Intergovernmental Agreement are currently underway. Negotiations on the NASA-RSA Memorandum of Understanding will begin later this summer.

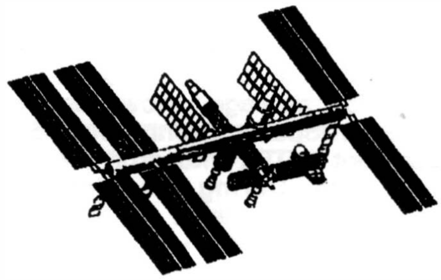
Activities included in the $400 million contract expand on an ongoing cooperative programme under the Human Space Flight Agreement. That agreement, concluded in 1992, provides for a US astronaut flight on Mir for three months and a Space Shuttle to dock with Mir in 1995. Key elements of the $400 million contract include:

- US astronauts will spend up to 21 additional months on board the Russian Mir station, giving a new generation of American astronauts and scientists their first experience with long-duration space flight.
- The US Space Shuttle will dock as many as nine additional times with the Mir station, delivering astronauts and research instruments. NASA will gain fundamental experience in joint operations: risk reduction, command and control, docking the Shuttle with large structures in space, performing technology experiments, and executing a joint research programme.
- The implementation of a joint research programme on board Mir, including astronauts and cosmonauts and US and Russian experiments. The Russian Spektr and Priroda research modules will be extensively used.
- The Russians will provide flight-proven equipment, including several docking mechanisms for use with Mir and later with the International Space Station.
- Joint development of the Solar Thermal Dynamics, a newer and more efficient way to generate electrical power in space.
- Joint technology demonstrations of systems that may be used on the International Space Station.
- Demonstrations of joint operations and activities, such as Extravehicular Activity (EVA).
- Up to $20 million to support Russian scientists engaged in joint scientific and research programmes to support science, technology and engineering on board the Mir Space Station.
- Initial development funding for the FGB module that NASA will purchase for use on the International Space Station. ■

Approval for Space Station

$2.1 billion Request for Next Year Survives

On 29 June, the House of Representatives rejected by a 278 to 155 majority a measure to terminate the International Space Station and move funds to other NASA programmes. A year ago a similar effort to end the space station project was defeated by only one vote.



The vote was preceded by a two-and-a-half-hour debate in which opponents repeated their arguments that $11.4 billion had already been spent on the project with very little to show in return and at the expense of other vital NASA programmes. They argued that the estimated $30 billion laboratory was too costly and could put the US in a compromising position with a country whose political and economic systems were potentially fluid.

Supporters pointed out that the programme had been drastically reorganised in the last year and was on a realistic working footing. To halt it now would curtail the shuttle programme and end 30 years of progress in manned space flight.

Vice-President Al Gore, who had been championing the space station's case, said that the vote cleared the way for a new era of space exploration and cooperation with international partners, including Russia. In a statement he said, "the strength of the House vote signals the end of doubt about America's commitment to space exploration".

The increased support for the station shown by the vote was attributed to the pact signed earlier in June between the US and Russia to cooperate in building the station in collaboration with Canada, Japan and Europe with a supposed saving to the US of $2 billion.

The appropriations package, of which the space station is a part, is due to come up in the Senate where opponents of the station will again try to stop it. The fight is far from over.■

Shuttle-Mir Update

Mission Mir	STS	Vehicle	Launch
			1995
Flyby	63*	D	February
01	71**	A	May
02	74	A	October
			1996
03	77	A	April
04	80	A	August
05	81	D	September
06	83	A	December
			1997
07	84	D	January
08	87	D	May
09	89	A	September
10	91	D	November

* Crew: Wetherbee, Collins, Foale, Voss, Harris and Titov

** Crew: Gibson, Precourt, Baker, Dunbar and Harbaugh. Solovyov and Budarin will be taken to Mir. Thagard, Strekalov and Dezhurov will be brought back to Earth.

A: Atlantis D: Discovery

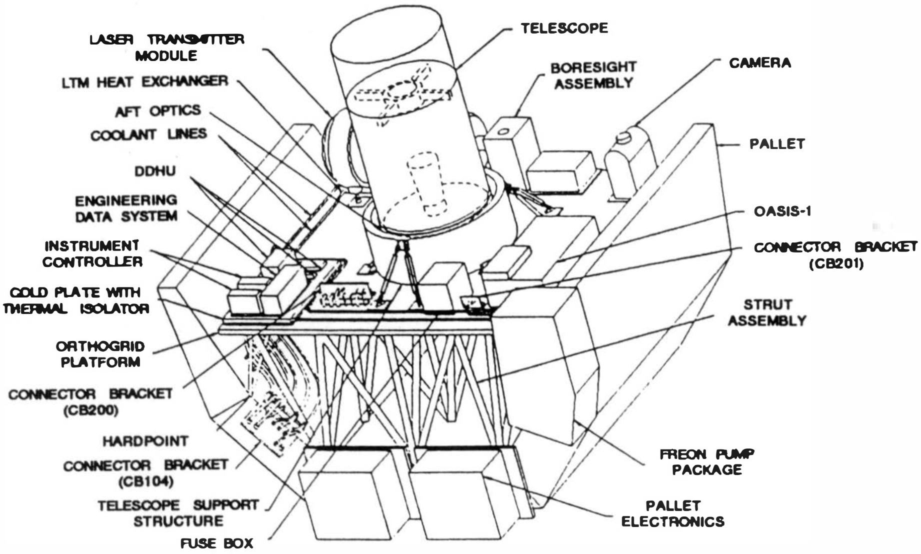
See *Spaceflight*, May 1994, p.146.

ANNE VAN DEN BERG

– STS-64 Payload

In-Space Lidar

In September, the Space Shuttle Discovery on mission STS-64 is scheduled to carry an Earth-observation package, known as the Lidar In-Space Technology Experiment (LITE), into orbit for the first time. During the nine-day mission, the crew of six will employ a laser radar - or 'lidar' for short - to make precise measurements of the abundance of aerosols in the stratosphere and troposphere, cloud top heights and atmospheric temperatures and densities at altitudes of 10 to 40 km. ***Ben Evans*** **has details of this upcoming shuttle mission.**



BY BEN EVANS
West Midlands, UK

LITE Instrument

During a typical on-orbit observing session, the laser beam would leave the LTM (Laser Transmitter Module) canister and pass into the BU (Boresight Unit), which ensures that both the transmitter and the telescope receiver are correctly aligned and are monitoring the same portion of the atmosphere. After impinging on the particular target of interest in the atmosphere, the reflected energy would be collected by the TR (Telescope Receiver). The Cassegrain telescope consists of a 37.25-inch-diameter primary mirror made from beryllium, and a 12.25-inch-diameter secondary mirror made from fused quartz. Mounted beneath the TR is a honeycomb-shaped aft optics bench whose purpose is to house the signal-processing and instrument-control electronics as well as a beam-splitter device which divides the incoming light into the three related infrared wavelengths which the neodymium:YAG (neodymium: yttium aluminium garnet) laser emits.

Two identical laser transmitters were incorporated into the final design to provide insurance in the case of one unit failing. Although either laser is available for use, power reserves aboard the Shuttle are insufficient to simultaneously operate both units.

The two other pieces of hardware on the LITE instrument are the Camera and the OASIS (Orbiter Experiments Autonomous Supporting Instrumentation System). The former has a wider field of view than that of the TR and will be used to conduct a photographic survey of the groundtrack in conjunction with the lidar observations.

OASIS, which has flown before, will be used to gather data relating to the environmental conditions surrounding the LITE instrument during the ascent and entry phases of the Shuttle mission.

The entire LITE assembly is supported by an orthogrid, which provides a stable platform from which the instruments can perform their precise observations. The orthogrid is attached by a system of 52 struts to the British Aerospace-made Spacelab Pallet. Although not directly associated with the LITE instrument, the U-shaped Pallet provides mechanical, thermal, avionic and power services to the payload. These pallets, which measure three metres in length by four metres in diameter, are a standard feature of Shuttle operations.

LITE Payload

The payload can be classified under only two headings: the LITE instrument itself and the Enhanced Multiplexer-Demultiplexer Pallet (EMP). The latter is based upon the Spacelab Pallet and acts as the instrument's interface with the Shuttle's mechanical, thermal-control and command-and-data-handling services. The combined weight of the instrument/EMP system amounts to 5,209 lb, with an anticipated power consumption of 3.03 kW.

Other associated systems include the Freon Pump Package (FPP), which is mounted on the upper-port side of the Spacelab Pallet and serves to link the LITE system with the Shuttle's freon coolant loop mounted in the payload bay. The temperature of the instrument is regulated by a continuous flow of freon and radiators located on the inside of the two payload bay doors.

The main pallet electronics are mounted in the bottom area of the EMP and include the Smart Flexible Multiplexer-Demultiplexer (SFMDM) and the Power Control Box (PCB). The former is capable of accepting commands from either the orbiter or from ground-based personnel who are able to operate the instruments as well as downlinking condensed science data at a rate of 20.5 kbits/s.

First LITE Mission

The maiden flight of the LITE payload on mission STS-64 will get underway with the lift-off of the Space Shuttle Discovery from Pad 39B at the Kennedy Space Center (KSC) in September 1994. The spacecraft will enter an orbit approximately 140 nautical miles high, inclined at 57° to the equator.

The astronauts' workload for Flight Day One promises to be extremely hectic since it requires the activation of the entire LITE-1 payload within hours of reaching orbit. When the instruments are powered-up, they will automatically enter a thermal-stabilisation mode which enables them to settle down to their correct operating temperatures. This mode could last for up to three hours, depending on the initial temperature of the system when it reaches orbit.

When the thermal adjustment is complete, the LITE system will place itself in a standby mode and await a command from the orbiter or the ground to enter the data-take mode. During typical activities, the instruments will alternate between standby and data-take modes, the main difference being that the LTM does not emit laser pulses when in standby mode. The mission schedule calls for two data-takes per day throughout the entire nine-day period, each of which will last for approximately 4.5 hours or three orbits of the Earth.

The LITE-1 mission will perform lidar observations to cover most of South America, all of Central America, most of Africa, and parts of India, China and Australia. The Shuttle will fly over water for approximately 70% of each orbit, conducting observations during roughly-equal periods of sunlight and darkness. The main study areas consist of climate, radiation budget (including the transfer of mechanical and thermal energy between the ocean and the atmosphere), large-scale cloud formations in the Western Pacific Ocean and off the western coasts of South America and Africa, the transport of Saharan dust by westerly Atlantic winds, and the aerosol content of the troposphere above the Amazon jungle.

Final deactivation of the STS-64 payloads, including LITE-1, will take place a few hours before the scheduled landing.

Following the experience gained by the LITE series of missions, it is hoped that a long-term array of lidar sensors will be placed into Earth orbit during the early part of the next century and so provide a fitting conclusion to this area of NASA's Mission to Planet Earth. ■

GOES-8

Long-Awaited "White Knight" of US Weather Forecasting

Weather forecasters in the United States breathed a sigh of relief when GOES-8 (Geostationary Operational Environmental Satellite) was successfully launched in the pre-dawn hours of 13 April 1994. An Atlas 1 rocket lit up the night sky as it roared into space at 2:04 AM EDT from Pad B of Launch Complex 36 on Cape Canaveral Air Station carrying the eagerly anticipated replacement to a hobbled pair of weather satellites.

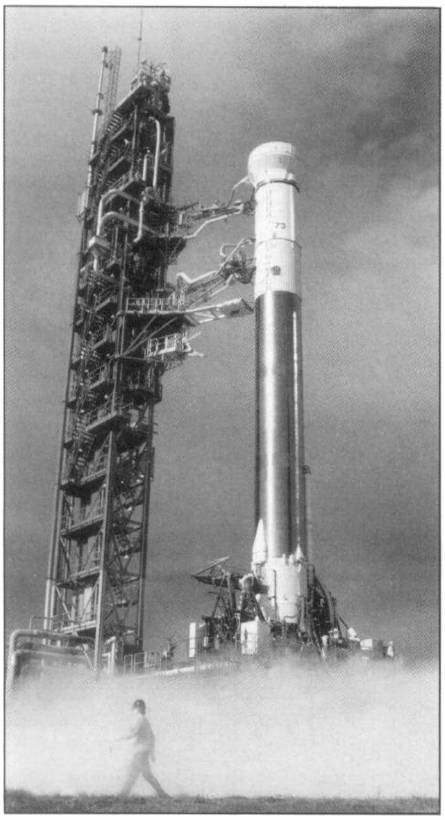
BY ROGER G. GUILLEMETTE
Rhode Island, USA

Introduction

The launch of GOES-8 could not have come at a better time for anxious U.S. weather officials. This new satellite is more than five years late in reaching orbit, the victim of "pushing the state of the art," according to Dr Elbert W. "Joe" Friday, Director of the National Weather Service. As delivery schedules slipped, project costs more than quadrupled from an initial estimate of $276 million to over $1.1 billion for the five satellite programme (exclusive of launch costs).

The first in a new generation of five advanced weather satellites known as the GOES I-M series, GOES-8 will begin returning imagery just in time for the Atlantic hurricane season. As an operatonal satellite in orbit it will be designated GOES-I. Although a six-month period of testing is planned before the spacecraft is declared operational, forecasters at the National Hurricane Center in Miami, Florida will have access to the early, uncalibrated data to aid in their efforts to track and predict movements of hurricanes which normally form in the summer and early autumn.

Atlas/Centaur 73, minus its payload, being prepared on 7 March 1994 for a wet dress rehearsal in which both the Atlas booster and Centaur upper stage were tested by being fuelled and pressurised to flight pressures. NASA



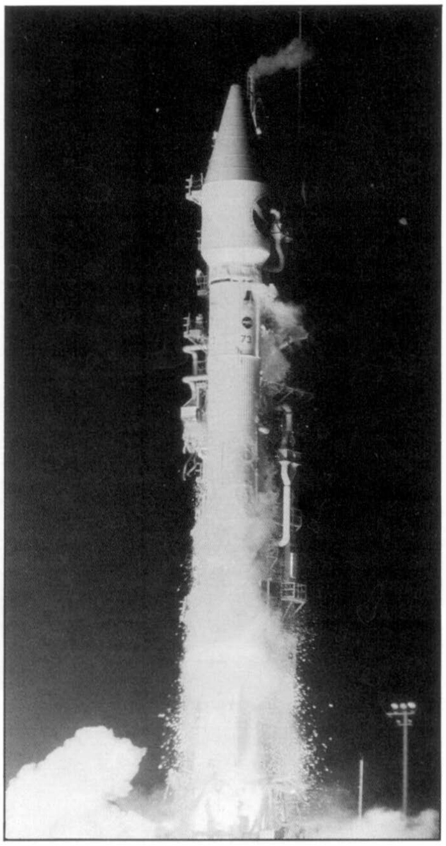
Delays and Failures Hamper Forecasters

For the past several hurricane seasons, U.S. meteorologists have been relying on a pair of aging satellites to provide the images and data required to track the powerful storms. "We've been sitting on the edge of our seats," confided Dr Bob Sheets, Director of the National Hurricane Center.

Normally, a pair of GOES satellites is required to provide coverage of the United States; the "East" satellite monitors North and South America and most of the Atlantic Ocean, the "West" satellite covers North America and the Pacific Ocean basin. Anticipating that the first new-generation GOES I-M would be operational in 1989, the National Oceanic and Atmospheric Administration (NOAA) did not order any spares after its final "older-model" satellite, GOES-G, was destroyed during a 1986 Delta launch vehicle failure. However, when the GOES-6 spacecraft unexpectedly failed in 1989, the United States was left with only a single operational geosynchronous weather satellite (GOES-7).

The GOES-6 failure forced NOAA to reposition its sole operating geosynchronous satellite, GOES-7, to a point midway over the continental United States. In August 1991, the European meteorology coalition, EUMETSAT, loaned its spare Meteosat-3 to NOAA to supplement Atlantic coverage. Although still operational, both of the current weather satellites have far exceeded their design lifetimes and could fail at any moment. GOES-7 is out of manoeuvring fuel, causing its orbital inclination to change each day, while Meteosat-3 has its own technical problems.

A GOES-8 launch failure would have been catastrophic, but weather officials had developed a set of "No GOES" contingency plans just in case.



The 14th commercial Atlas/Centaur leaves the launch pad at 2:04 am EDT on 13 April 1994. At the same time ice that had accumulated on its surface shattered.
PETER GUALTIERI, WEST KENTUCKY NEWS

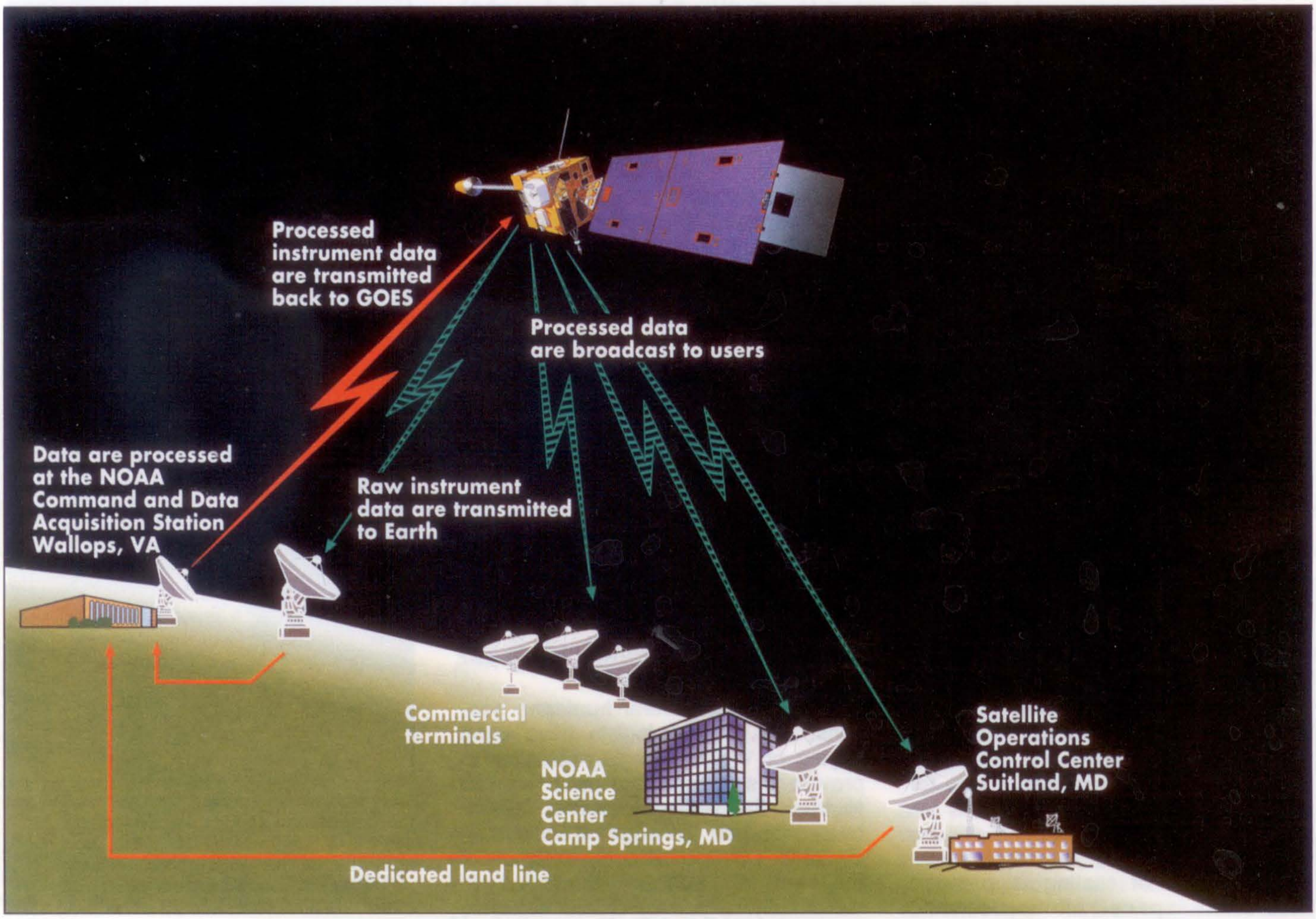
Lower than Expected Orbit

The General Dynamics combination of an Atlas 1 launch vehicle (AC-73), coupled with a Centaur upper stage, placed GOES-8 into a lower orbit than anticipated, about 810 km short of nominal.

Mission officials were quick to emphasize that the initial orbit attained, 37211 x 144.5 km, was perfectly acceptable since the minimum apogee for a geosynchronous orbit is only 31092 km. GOES Program Manager McGunigal termed the Atlas-1 performance shortfall "irrelevant," but added that the lower orbit translates to a predicted spacecraft lifetime of 8.6 years instead of the anticipated 9.2 years.

This was the seventh launch of the Atlas-1 configuration. The Rocketdyne first stage engines produced 199,000 kg of thrust at liftoff and burned for 266 seconds. Liftoff weight was 166,264 kg, including the payload.

The second burn of the Centaur upper stage lasted 102 seconds, 5 seconds longer than predicted, employing a new strategy for geosynchronous satellite launches which calls for the RL-10 engines to fire until all of their fuel is expended. The first burn lasted 313 seconds and was in-



Instruments on board GOES scan the Earth for information and transmit their observations to NOAA's Command and Data Acquisition station for processing. The processed data are transmitted to GOES for rebroadcast to the data user community. NOAA/NASA

tended to place the GOES-8 into a parking orbit of 129 x 350 km. The Centaur and its payload coasted for about 13.9 minutes before the second RL-10 firing boosted the satellite to the lower than expected geosynchronous transfer orbit.

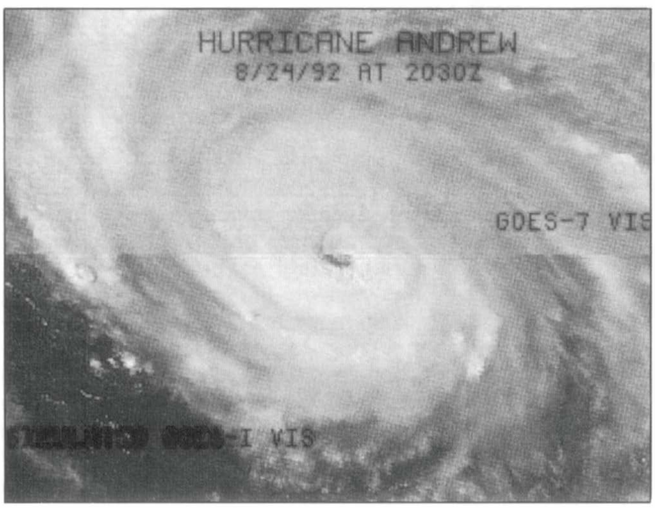
NASA no longer launches expendable vehicles of its own; instead, it purchases launch vehicle services from private manufacturers such as General Dynamics. The contractual obligation of General Dynamics for this mission was to deliver the spacecraft into a minimum orbit of at least 28,157 km. If that had not occurred, the US Government would have been reimbursed the cost of the launch vehicle and services, but not for the cost of the payload itself. The United States does not purchase insurance for government-owned payloads, preferring to "self-insure".

Boost to Final Orbit Delayed

Mission officials were given quite a scare when a high temperature reading in the GOES-8 propulsion system forced an abort of the first thruster burn on 14 April, one day after launch. The over-temperature condition occurred about 8 minutes into the first of four planned firings of the satellite thrusters, intended to circularize the GOES geosynchronous orbit.

After careful analysis, spacecraft engineers determined that they had misinterpreted telemetry from the spacecraft and that the thrusters had been operating normally. Several additional thruster firings boosted the GOES-8 spacecraft to reach its final geosynchronous orbit on 27 April 1994, two weeks after launch.

This split image shows Hurricane Andrew as seen from GOES 7 along with a simulation of the view from GOES I. NOAA/NASA



New Generation of Satellites

The GOES I-M series, developed by Space Systems/Loral, are by far the most advanced and expensive weather satellites ever developed. Weighing 2105 kg, these spacecraft are expected to provide weather images of unprecedented clarity to meteorologists, sharpening and brightening the cloud formations that are seen on the daily television weather reports. GOES I-M satellites can distinguish 1,024 shades of grey in visible cloud images, as opposed to only 64 shades from the old GOES-7.

The GOES I-M class will take advantage of a fundamental design change. The old GOES spacecraft spun constantly to maintain stability, scanning a narrow strip of Earth during each revolution. In contrast, the new GOES I-M will be stabilized in a fixed attitude by employing gyroscopes and other devices, enabling the spacecraft to gaze incessantly at an entire hemisphere. Visual and infrared images, along with radiometric observations, will be returned four times an hour, while the elimination of the spinning motion greatly improves the quality

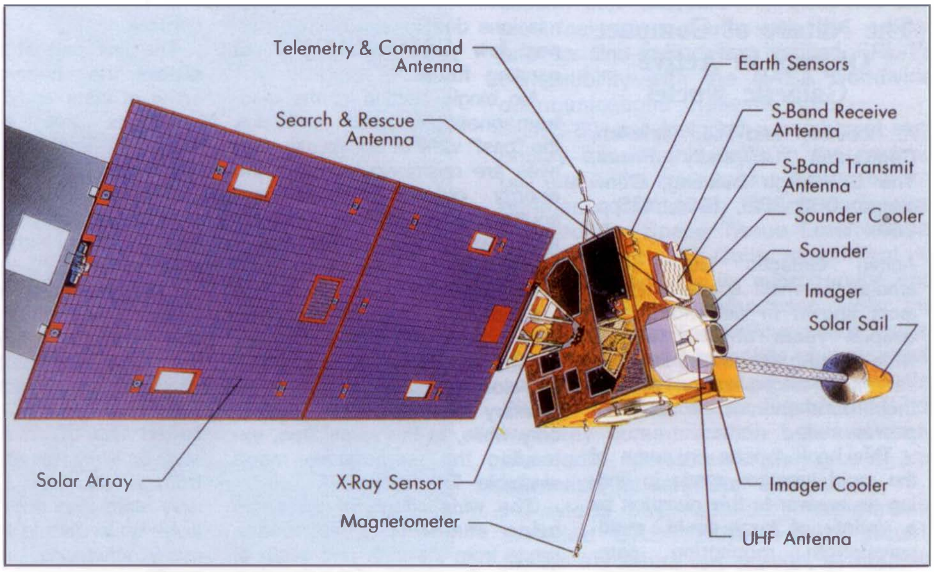
of those images. Other instruments measure Earth emitted and reflected radiation from which atmospheric temperature, winds, moisture and cloud cover can be determined.

One major enhancement of the GOES I-M is the ability to "zoom in" on trouble spots, such as hurricanes or potentially tornado-producing thunderstorms, providing detailed, close-up images of areas as small as 1000 sq km every six minutes. This "zoom" feature should permit hurricane forecasters to track those storms with unparalleled accuracy and may actually facilitate predictions of when and where a tornado may form.

"The average lifetime of a small cloud is less than 30 minute - with the old satellite we would miss this event," said Dr Friday. "Now, we can receive more detailed information on the growth of clouds. This is important when you are watching development of a thunderstorm."

Each GOES I-M satellite will carry two major instruments, an Imager and a Sounder, which provide high-resolution visible and moisture profiles of the atmosphere. The Imager will produce images of greater clarity and sharpness in the visual wavelengths, along with the ability to scan a wider range of the infrared spectrum. The Sounder is considered to be the enhancement with the greatest potential to improve weather forecasts. It can peer through vertical "tunnels" of the atmosphere, precisely measuring temperature and humidity at different layers, including minute variations in the temperature of carbon dioxide in cloud formations.

"We will be able to track vertical temperature and moisture patterns in the atmosphere," explained Dr Friday. "This will enable us to see how clouds develop."



An annotated picture of GOES in its deployed configuration. To the left of the solar array and extending off the picture is the Trim Tab which is a silver panel that allows adjustments for solar pressure and solar wind to be made to keep the spacecraft stable in its orbit. NOAA/NASA

"Cold air is denser, warm air is lighter, and there is a tendency for a storm to move into lighter air," added Mr McGunigal.

The imaging and measurement instruments on the GOES I-M satellites are designed to operate simultaneously and independently, allowing forecasters to utilize multiple measurements of weather phenomena.

Weather officials are delighted with the features of the new hardware, with only one minor enhancement left on their "wish list." if cost and schedules were no object, "the only feature i would have added (to the GOES I-M) would have been a second Imager," noted Dr Friday. "Now, you can't zoom in on a specific area (like a hurricane) without losing hemispheric coverage."

Extensive Satellite Testing

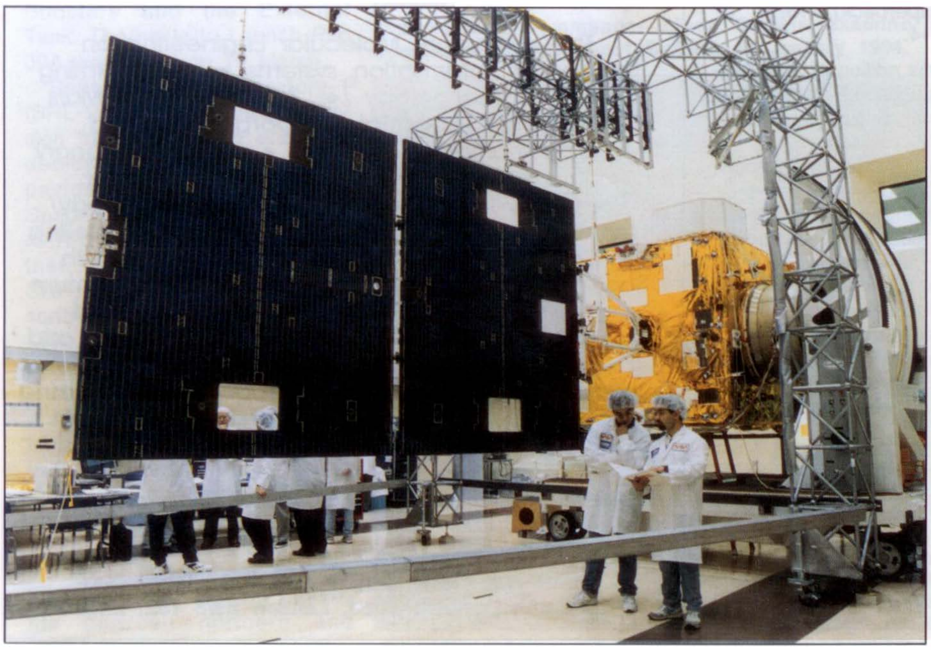
The GOES-8 solar arrays were deployed about 8.7 days into the mission. This was followed by about three weeks of "outgassing", the process that allows foreign particles and contaminants to float out of the spacecraft. The cooler cover doors opened after about 29 days, the detectors then being cool, after which the infrared detectors are tested.

Evaluation of the Imager and Sounder begins about five weeks into the mission with the first images returned in July 1994. if all goes well, the GOES-8 spacecraft will be declared operational in October 1994.

GOES-8 will not be fully tested until just before the end of the 1994 Atlantic Hurricane season, but some uncalibrated imagery and data will be made available to the National Hurricane Center early this summer. Dr Bob Sheets and his colleagues are anxiously looking forward to the images, but there are no plans to rely on it until the six-month calibration and check-out period is completed.

Dr Sheets is cautiously optimistic but adds, "Wait until it's working and then i'll release some of the tension we've had over the past few years."

At the Astrotech processing facility in Titusville, Space Systems/Loral workers test the solar arrays on the GOES-I spacecraft. The checkout included a first motion test of the arrays, where they are released about six inches, followed by a manual walkout and stowage to insure the arrays are ready for flight. NASA



Acknowledgements

I wish to thank the dedicated professionals at the NASA/Kennedy Space Center Press Center for their help and assistance in covering this mission. Special recognition is due to Ms Leslie Williams, Accreditation Secretary; Ms Kay Grinter, Librarian and Tour Escort; and Ms Margaret Persinger of the Photo Library. Thanks are also due to Ms Terri Bracher, Chief of Media Relations for the U.S. Air Force's 45th Space Wing.

Book Notices

The Nature of Compact Objects in Active Galactic Nuclei

A. Robinson and R.J. Terlevich, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 435pp, £40.

Active Galactic Nuclei are among the most spectacular objects known in astronomy yet, despite years of intense and wide-ranging research, there is still much discussion on what is their fundamental source of power.

This book reports on some of the rapid progress made in finding an answer to this question by a variety of large-scale, multi-wavelength monitoring campaigns and by the latest generation of satellite-borne observations. Although it is a rapidly-evolving area, problems still abound. For example, what is the evidence for and against unified schemes for AGN: how do the AGN populations evolve over cosmological time-scales, what does the variability of their UV and X-ray emissions signify and why is it that the conventional black hole-accretion disk paradigm is now being so strongly challenged by the starburst hypothesis?

This volume centres on five main topics viz isotropic emissions and unified schemes, AGN luminosity functions and their implications for the power source; the structure and dynamics of the broad emission lines: the variability and spectral energy distribution of the high-energy continuum and their implications for accretion disk models and, lastly, theories on observed properties of jets in AGN. Each area has seen important observational or theoretical advances recently which have fuelled further debate as to the nature of these "compact objects".

Infrared Astronomy

A. Mampaso, M. Prieto and F. Sanchez, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 415pp, £40.

Infrared-Astronomy has seen a revolution over the past 20 years due to the widespread availability of large, very sensitive arrays and the success of IR satellites (IRAS in particular), with further missions due for launch over the next few years promising a yet exciting future.

No single section of the electromagnetic spectrum provides the "best" view of our galaxy. Our eyes are optimised to detect the energy output from thermal sources with a surface temperature near 6,000 degrees K, but X-ray and UV sensitive eyes would "see" only hotter objects, while infrared or microwave eyes would "see" only cooler objects.

Infrared astronomy provides the closest and greatest complementary match to optical astronomy while, at the same time, extending the temperature range available for study.

The wide scope of problems being studied by this means range from the birth and death of stars to the nature of the tiny dust grains that permeate both our own galaxy and other galaxies. They also involve problems about the existence or otherwise of brown dwarfs, extra solar planets and other sub-stellar objects.

The structure of star-forming regions, particularly, is highly complex and rarely reveals isolated interstellar clouds. Observations in the near infrared also show that many young stars have companions, thus deferring still further the conclusive identification of genuine proto-stars.

The nine chapters of this book provide both an excellent introduction and a thorough and up-to-date review of developments in all these fields.

The Stars: their structure and evolution

R.J. Tayler, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 241pp, £30.00 (hardback), £12.95 (Paperback), ISBN 0-521-45885-4.

This is a new edition of a widely-used text published originally in 1970 and which has now been substantially revised.

Stars are the main known constituent of the Universe and they are studied through light which they emit. This book describes the manner in which knowledge from many other branches of physics, such as gravitation, thermodynamics, atomic physics and nuclear physics, can be combined to enhance our understanding of their structure and evolution.

The first part of the book describes the observational properties of stars and discusses the equations that govern their structure. The second summarises recent theoretical work on stellar evolution. The successes of the theoretical aspects are stressed but with mention of phenomena that are still not yet completely understood.

New topics in the revised edition include a comparatively brief account of the birth, life and death of stars which, fortunately for some readers, makes only limited use of advanced mathematics. Work on the mass loss from single stars and close binary stars also underline the aim to be up to date in an area where many advances are still being made.

Preservation of Near-Earth Space for Future Generations

J.A. Simpson, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 247pp, £50.00, ISBN 0-521-44508-6.

This book addresses the questions which need to be asked before man-made space debris circling the Earth - from dust particles to rocket casings and even radioactive materials - becomes a critical problem.

A number of well-known specialists address problems and policies concerned with the preservation of near-Earth space, their contributions covering both technical and the economic and legal issues concerned, including the enforcement of monitoring of international agreements reached and the resolution of any disputes which arise.

The opinions expressed represent the views of all of the major nations currently involved in space, thus providing both an authoritative and comprehensive review of the problems involved and possible solutions to the growing space debris headache.

The Illustrated Guide to the Night Sky

R. Kerrod, Headline Book Publishing Ltd., 338 Euston Road, London, NW1 3BH, 1993, 160pp, £19.99, ISBN 0-7472-0903-0.

This is a book for everyone who would like to know more about the stars without having to wade through complicated diagrams or technical text. Rather than

These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

take a conventional approach the book invites its readers to go outside to begin observation right away, starting with a general view of the night sky and then moving on to using more detailed star maps for each month, with key constellations acting as heavenly signposts.

The star maps in the book are complemented by a planisphere. One has only to look through its "window" to see the main stars visible in the heavens every night of the year.

The emphasis is strictly on personal observation i.e. what is visible to the naked eye or through binoculars and telescopes.

Additional text describes the Moon, Sun and Solar System as well.

Suddenly Tomorrow Came... A History of Johnson Space Center

Henry C. Dethloff, US Government Printing Office, Superintendent of Documents, Mail Stop SSOP, Washington, DC 20402-9325, USA, 1993, 409pp, 116 illustrations, US$28.00, ISBN 0-16-0-43754-7.

In 1961, President John F. Kennedy answered the challenge of Sputnik and Yuri Gagarin by placing the United States on course for the Moon. The Manned Spacecraft Center (as Johnson Space Center was known until 1973) was built in Houston, Texas to train crews and ready spacecraft for the great adventure of space exploration and to provide an enthusiasm and expertise which reached beyond their labs and control rooms to the entire world.

This book begins by tracing the development of American rocketry. It then examines the decision to move the Space Task Group, a small team of engineers at Langley Research Center responsible for the Mercury program, to the new NASA center in Houston and describes the history of Johnson Space Center through the Mercury, Gemini, Apollo, Skylab, Apollo-Soyuz and Shuttle programs, concluding with a look ahead to space stations and to the Moon and Mars.

The Guide to the Galaxy

N. Henbest and H. Couper, Cambridge, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 265pp, £35.00 (Hardback), £17.95 (Paperback), ISBN 0-521-45882-X.

This is a guide to our own Milky Way Galaxy, written in non-technical language for the general reader and the amateur astronomer. A specially created map, locating the hundreds of interesting objects in the Milky Way, is supported by an excellent portfolio of colour photographs of its stars, star clusters and gas clouds.

The opening of windows beyond the optical spectrum has provided a totally new view of the galaxy and enabled it to be examined in greater detail than ever before.

The Guide opens with descriptions of the nature and structure of our galaxy as a whole. This is followed by text on the various types of objects which it contains, including possible black holes, globular clusters, stars of every type, regions of star formation, novae and their remnants and enigmatic objects at the galactic centre, as well as the giant halo surrounding the galaxy as a whole.

1994 European Space Directory (9th Edition)

Sevig Press, 6 Rue Bellart, 75015 Paris, France, 1994, 411pp, 890FF plus 25FF Handling and Mailing (18.60% VAT applicable to sales in France only), ISSN 0765-0574.

Publication of the 9th edition of this work testifies to its value as a source of up-to-date and accurate information in a continuously-changing space market. The overall mould of the Directory is unchanged: it is still divided into five major sections viz Editorial, Company Profiles, Minimum Listings, Who's Who and A Buyers Guide.

The Editorial section contains a paper on the Alpha Space Station and the Nanosatellite revolution. There is also a 1993-1994 Space Chronology, which details contracts awarded to Industry by ESA, and sections on World Space Programmes and Budgets and Satellite Launching Sites.

The Directory offers 270 in-depth texts on Company Profiles, practically all in Europe, detailing data such as management, capital, turnover, specialisations and subsidiaries.

In addition, more than 300 companies are listed by name, address, phone and fax numbers etc, in a section conceived to provide an opportunity for the inclusion of Institutions and Universities with limited funds and for small space companies with restricted budgets.

As regards key personnel, nearly 1,500 names and positions in both European and North American Space Industries are listed.

How the Universe Works

H. Cooper and N. Henbest, Dorling Kindersley Ltd., 9 Henrietta Street, Covent Garden, London, WC2E 8PS, 1994, 160pp, £12.00, ISBN 0-7513-0080-2.

Astronomy has always had a very practical basis and has been used for centuries for timekeeping, navigation and the calendar, a tradition which can be carried on by young people using this book with its emphasis on techniques that range from mapping distant worlds to building a star theatre. Hundreds of practical experiments are described, using the simplest of materials from around the home or garden, so forming an attractive work which is sure to lure many young people into an active involvement with science.

All the experiments are profusely illustrated step by step, in colour, so they may be followed easily. Accompanying text explains the principles behind the experiments and is augmented by other useful background information.

This book is suitable for key stages 2, 3 and 4 of the National Curriculum.

Solar and Stellar Activity Cycles

P.R. Wilson, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 274pp, £40.00 (Hardback), ISBN 0-521-43081-X.

How can one predict the parameters of future solar cycles, estimate their terrestrial effects, determine the role of dynamic theory in the cyclic activity of the Sun and what does a chaos theory imply as regards stellar cycles? This monograph attempts to answer such questions in a unique survey of our present knowledge of solar activity which is extended to cycles which, quite clearly, must also exist in other stars. This review of our basic knowledge of the Sun, particularly of solar activity cycles, shows the importance of reliable future predictions and describes methods currently used to determine these.

The latest research into solar cycles is presented, with special reference to the maximum of Cycle 22. Also included are helioseismology, observations of the extended activity cycle and the polar field reversals, together with theoretical contributions from dynamo theory and chaos theory.

Voyager in Time and Space: The Life of John Couch Adams, Cambridge Astronomer

H.M. Harrison, The Book Guild Ltd., Temple House, 25 High Street, Lewes, East Sussex, BN7 2LU, 1994, 282pp, £15.00, ISBN 0-86332-918-7.

The Cambridge Astronomer, John Couch Adams, worked out the existence and position of Neptune in 1845 based on disturbances to the orbit of the planet Uranus. Unfortunately, considerable delay took place in making the observations to confirm his calculations. In the meantime, and to his dismay, calculations by the Frenchman, Le Verrier, were published first so he received all the acclaim.

Undaunted, Adams forged a distinguished career in mathematics and astronomy, voyaging not only in space but in time, and playing an instrumental part in setting up the Greenwich Meridian.

This, the first attempt at a full-length biography of an eminent astronomer, shows that his early academic life was undoubtedly dogged by the controversy surrounding the discovery of Neptune and which tended to eclipse the rest of his achievements.

This books sets out to redress the balance, charting his life from humble beginnings in Cornwall in 1819 and following him to his studies at Cambridge where he became an academic.

Through the extensive use of his diaries and letters the author provides an insight into his personality and private life, revealing Adams as not only a brilliant academic but a modest and gentle family man.

A final tribute appears in an extract from his Obituary, which reads "By the death of Professor Adams, England has lost the greatest mathematical astronomer she has ever produced, Newton alone accepted. . . ".

'Space Launchers' Competition

Space launch vehicles are often in the news and it is usually the names of the same few that occur again and again. But, how easy is it to put the right name to the right vehicle with only a simple outline to work on ? This month's competition gives readers an opportunity to find out and perhaps win a prize.

Prizes: The first correct entry to be opened after the closing date of 1 September 1994 will receive a copy of the book (published by the Cambridge University Press, 1993):

The Space Telescope - *A Study of NASA Science, Technology and Politics*
by Robert W. Smith

The runner up will receive a copy of the book (published by The University of Arizona Press, 1992):

Worlds in the Sky - *Planetary Discovery from Earliest Times through Voyager and Magellan*

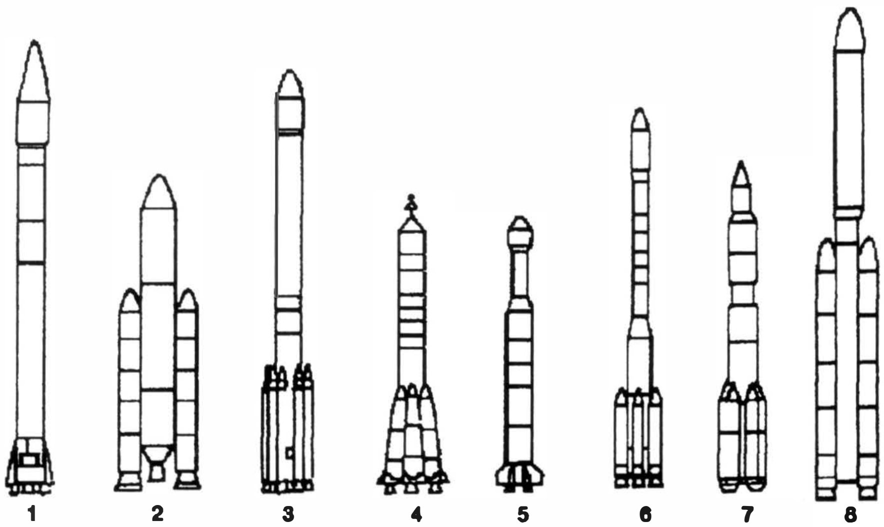
Three Consolation prizes are offered of the book:

Citizens of the Sky
by BIS Fellow Bob Parkinson

To Enter: Match up the following line drawings with the list of names below:

1. ....
2. ....
3. ....
4. ....
5. ....
6. ....
7. ....
8. ....

Ariane 4; Ariane 5; Atlas II; Delta II; Long March; Proton; Soyuz; Titan IV.



Post to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England
To arrive by first delivery on 1 September 1994.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

Title/Name ....

Address ....

....

....

Spacewalk in Noordwijk

Noordwijk Space Expo is a unique cooperative venture between private enterprise, the European Space Agency and European space industry. It was opened in June 1990 by Her Majesty Queen Beatrix of the Netherlands and was the first and, so far, remains the largest permanent space exhibition in Europe.

The objectives of the Noordwijk Space Expo are, on the one hand, to present in collaboration with ESA a permanent and regularly updated exhibition about space in all its facets, and on the other hand to create an additional attraction in the seaside resort of Noordwijk.

The initiative for setting up the Noordwijk Space Expo (NSE) came originally from a group of Noordwijk residents. It is operated by a private trust of the same name, the holdings also belonging to this Trust. Through a formal agreement, the trust works closely together with the European Space Research and Technology Centre, ESTEC, the technical heart of the European Space Agency (ESA). The close ties are moreover evident from the fact that Noordwijk space Expo also serves as the official Visitors' Centre for ESTEC.

The Noordwijk Space Expo building is located close to the main entrance to ESTEC, but on its own site. The interior of the Expo was designed by R. van Opdorp from Amsterdam. The arrangement of the exhibition was the cooperative responsibility of the NSE Trust and the ESTEC Public Relations Office.

Sponsorship

The exhibition itself covers an area of 1600 m^2, and there is also a coffee shop, a souvenir shop, an auditorium and two conference rooms. Obviously, a multi-million guilder project like this does not just happen. A significant proportion of the initial capital was provided by European space industry in the form of sponsorship. The Dutch Government, the Province of South Holland and various local authorities, including Noordwijk of course, also made funds available. In addition both ESA and industry have given their support in kind, for example by providing models and real hardware.

Themes

The Expo aims to give a dynamic and up-to-date view of space exploration together with a complete and spectacular view of the best of the European space effort.

Current space programmes and historical highlights are presented using models (many full size), photographs, text and film.

The exhibition centres around three themes: The History of Space Exploration, Europe in Space, The Future of Space Exploration. Focal points include:

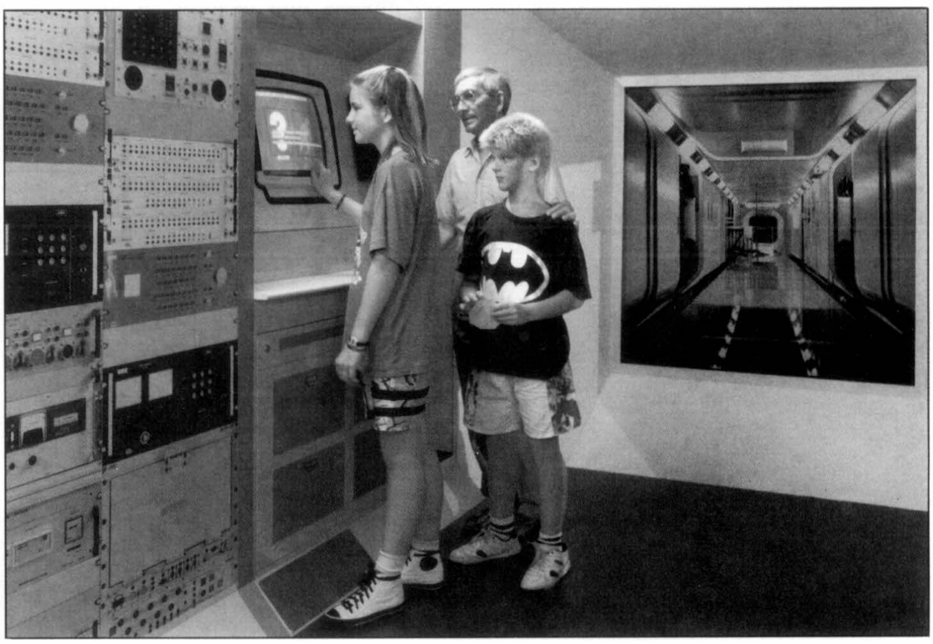
- A piece of Moon rock,
- A production model of the Ariane 1 propulsion bay;
- A test model of Giotto and an accurate scale model of the nucleus of Halley's comet;
- A gigantic satellite photograph of the Netherlands;
- A test model of the Ulysses spacecraft, now on its way to the Sun;
- A full-size model of the Columbus Module for the International Space Station to be launched in 2001;
- A test model of one of the very first European satellites ESRO-1, and
- A full-size model of the Apollo Lunar Module.

The visitor will also find a great many other models, many photographs of launchers, space vehicles and results of space exploration, interspersed with video monitors showing short films on various space-related topics. Sections of the exhibition are modified, changed or replaced regularly and within the permanent exhibition there are temporary exhibits on subjects of topical interest.

Taking the 'Spacewalk'

You enter through a dark, somewhat mysterious corridor with pictures

Interspersed among the models and photographs are video monitors on which visitors see short films on various space-related topics.



Astronaut Helen Sharman during a space education visit to Noordwijk Space Expo in 1992 captivates a young audience as she describes her experiences in space.

showing how mankind through the ages has been fascinated by the starry sky. Here you find Stonehenge and the Pyramids. The tunnel opens to another dark room where you find the founders of our modern view of the universe: Ptolemy, Copernicus, Galileo, Kepler, Brahe and first and foremost, of course, Newton. The discoverers of the planets Uranus, Neptune and Pluto are also found here.

Then from the darkness into the light of space exploration itself and in the next two domes are the founding fathers of space flight: Oberth, Tsiolkovski, Goddard, Von Braun and Korolev.

Pictures of the first space travellers look out at you as President Kennedy announces that the United States plan to put a man on the Moon.

Photographs of manned and unmanned space flight, lunar landings, space shuttles and the exploration of the planets are set against a full-size model of the world's first satellite, Sputnik 1, and a fantastic scale model of the Shuttle on its launch pad. From a balcony is an impressive view of the central core of the exhibition with its launchers and satellites.

To the left is a gallery of planets with a selection of the beautiful pictures of the planets and their moons taken by Mariner, Viking and Voyager spacecraft. There is also a wonderful series of large-format photographs of the Earth taken by the Landsat and Spot satellites. Space exploration is further represented by the Hubble Space Telescope and Giotto (with an accurate 1:20,000 scale model of Halley's Comet) and Hipparcos.

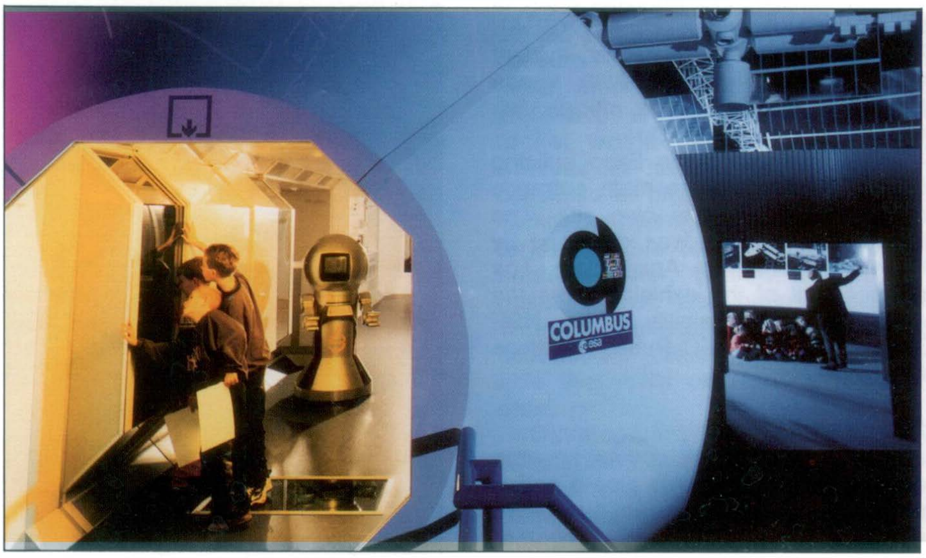
Launchers

A high point of the exhibition is the propulsion bay of the Ariane. This impressive engine block is surrounded by models and pictures of Ariane vehicles and almost all the other major launchers used for space exploration past and present.

Charts on the wall explain the complications of manned space flight to the Moon and of sending unmanned probes to the planets.

Past a test model of the gigantic Olympus satellite is the Earth observation section with impressive photographs of the Earth. On a monitor is the weather map of Europe just transmitted and behind is a full-size model of

A group of young visitors examine the interior of the full-scale model of the Columbus Attached Laboratory. ESA



the weather satellite itself.

Space Station

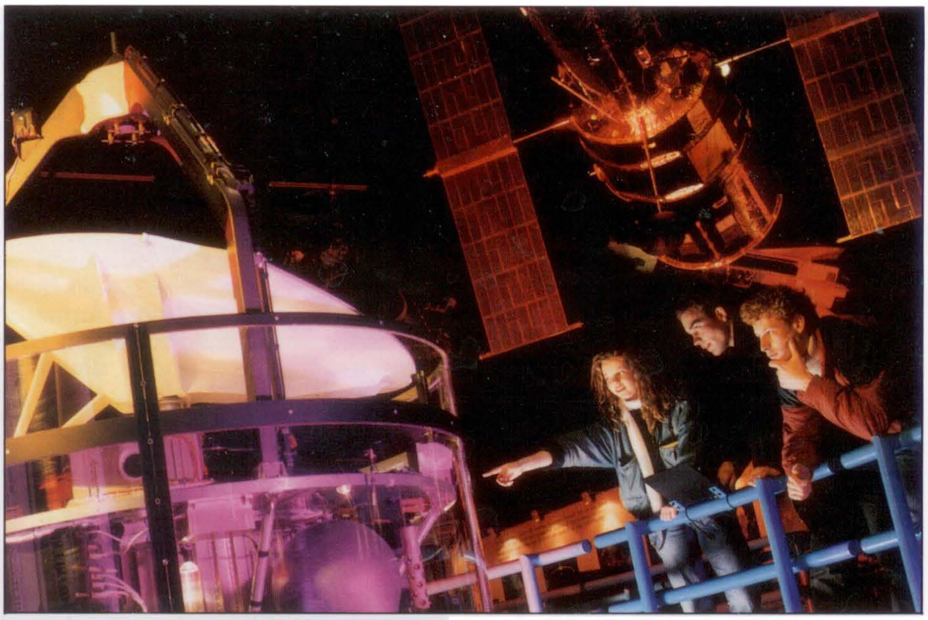
A test model of Ulysses, currently on its way to the polar regions of the Sun, and a scale model of the new European Ariane 5 space launcher are seen on the way to the next highlight: a full-scale model of the Columbus Attached Laboratory, which will form part of the International Space Station at the turn of the century. The module on display is a hybrid version, fitted out partly as a laboratory module and partly as a habitation module and it gives a very clear idea of what it is like to live and work in space.

The last dome is devoted to American and Russian manned space flight with detailed scale models of the Apollo spacecraft and of the Mir space station with docked Soyuz, Progress and Kvant modules. An impressive display is a full-size Apollo 11 Lunar Module from which two astronauts have just emerged ready to start surveying the lunar surface. At the same time a conversation between the astronauts and Mission Control (Houston) back on Earth is relayed. In a display case in the foreground are Moon boots and tools used by astronauts to investigate the lunar surface.

The exit from the Expo is through the specially designed ESA section with models of virtually all the spacecraft launched by ESA.

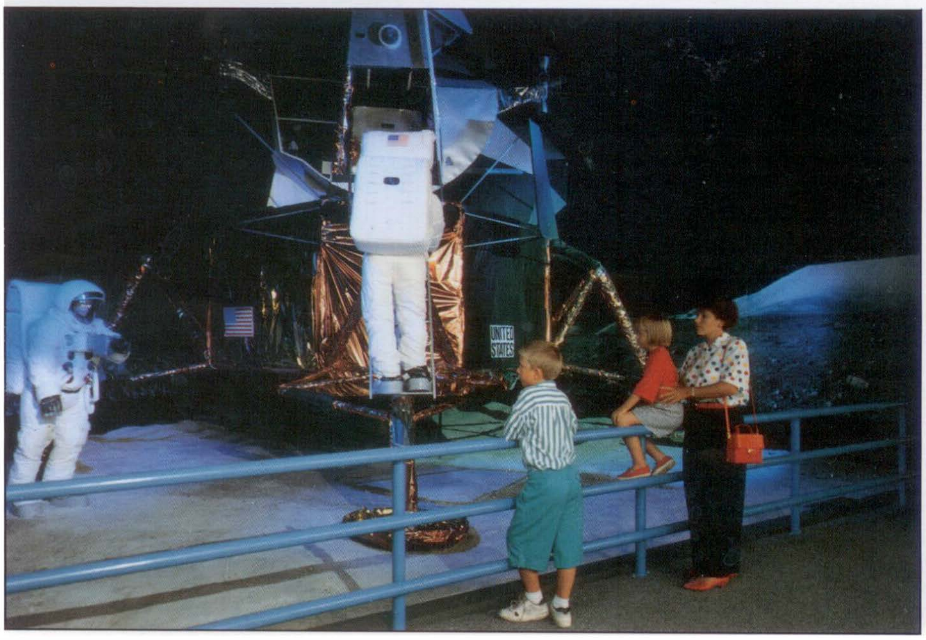
Young British visitors (aged 6-12) may qualify for the Expo's Astronaut Diploma, which is signed by Astronaut Helen Sharman, by answering 20 questions on a 'Space Quest' form as they go round the exhibition.

The exhibition is open daily from 10:00 to 17:00 hours except on Monday when it remains closed. ■



Above: **From a balcony there is an impressive view of the exhibition's launchers and satellites.**

Left: **For this young visitor there is nothing like getting the feel of a real rocket engine in the Ariane rocket propulsion bay.**



Below: **Joining the two Apollo 11 astronauts (in imagination, at least) as they emerge from their Lunar Module.**

(All photos are by courtesy of ESA)

Finding Out About...

Rocket Propulsion

Part 2 - Advanced Technology

In Part 1 we looked at chemical propulsion systems that are in current use. (See *Spaceflight*, June 1994, p.201). Three possible future forms of rocket propulsion are now outlined for which new technologies are available or under development.

Advanced Chemical Propulsion

All existing space launchers are *expendable*, meaning that they serve for only one launch and are not available for re-use. The Space Shuttle started a trend towards reusability by bringing back the expensive engines and electronics with the return of the Orbiter. A fully reusable launch system may operate more like an aircraft than a missile. There are a number of proposals currently being studied around the world and the British Aerospace HOTOL is a good example.

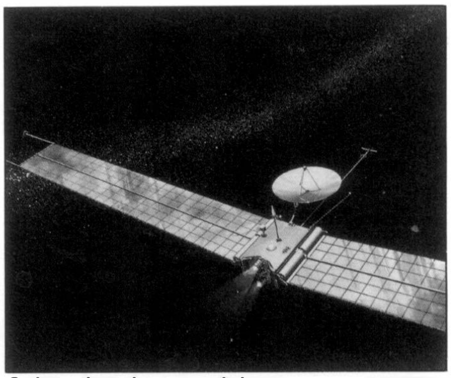
These advanced propulsion systems need to use liquid oxygen and hydrogen propellants on account of their high *specific impulse* (see Part 1 in ***Spaceflight***, June 1994, p.201). They must also have very light structures using advanced composite materials such as titanium reinforced with silicon carbide fibres and advanced plastics reinforced with carbon fibres. When the best engines and structures are combined in a space vehicle, calculations show that such a vehicle could just about reach orbit and return.

To improve this marginal performance many of the reusable launcher proposals exploit the air in the atmosphere, during the early stages of propulsion. HOTOL uses the Rolls Royce RB545 dual mode engine (see Fig. 1). When in the atmosphere, turbines, similar to those in jet engines, capture and compress the air. This makes the air so hot that it needs to be passed through heat exchangers to cool it sufficiently to be fed into a conventional rocket engine to be used in place of liquid oxygen. The heat from the air is transferred to hydrogen that is taken from the fuel tanks. This hydrogen gets hot enough to power the compressor turbines and may then be vented overboard or used in a combustion process.

Advanced launch systems such as HOTOL promise to reduce the cost of reaching orbit by a factor of between 5 and 10. Almost as important, they also offer much more regular launches without the extensive planning and preparation necessary for current rockets.

Nuclear Rocket Engines

Chemical reaction is one way of producing a hot gas. Another method is to heat the gas in a nuclear reactor, constructed like a rocket engine in the manner shown in Fig. 2. While the details of a nuclear reactor may differ significantly, in principle all steady state nuclear reactors are about the same. The propellant (for example, liquid hydrogen) is fed by the turbopump to the nuclear reactor, where it is heated by passing through the fuel elements. The hot gas is then expanded through a nozzle. Some or all of the propellant may pass through the tubes that make up the chamber wall, to cool it, before entering the chamber injector. As with chemical propellants, this is also referred to as regenerative cooling.



Solar electric propulsion. **HUGHES**

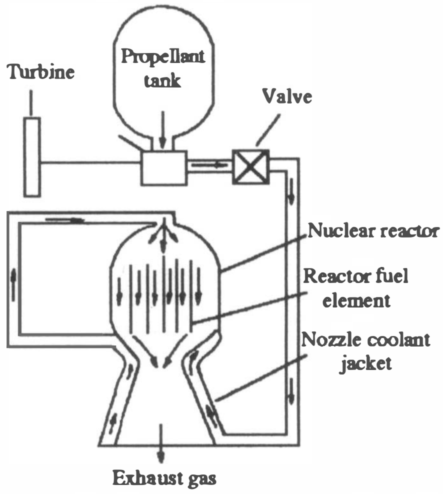


Fig. 2 Simplified schematic of a nuclear rocket engine.

To obtain maximum exhaust velocity, the preferred propellant is one that contains the highest energy per unit mass, which is hydrogen. The specific impulse of a hydrogen-based nuclear rocket would exceed 7850 Ns/kg, whereas the maximum obtainable with conventional propulsion is about 4610 Ns/kg. But hydrogen is not the only material suitable for a nuclear rocket engine. Water, carbon dioxide and methane have also been considered. Water may ultimately turn out to be the best nuclear rocket fuel due to its probable availability on Mars or in asteroids.

Development work has already taken place in anticipation of future applications to space exploration. During the 1960's the United States Rover programme demonstrated en-

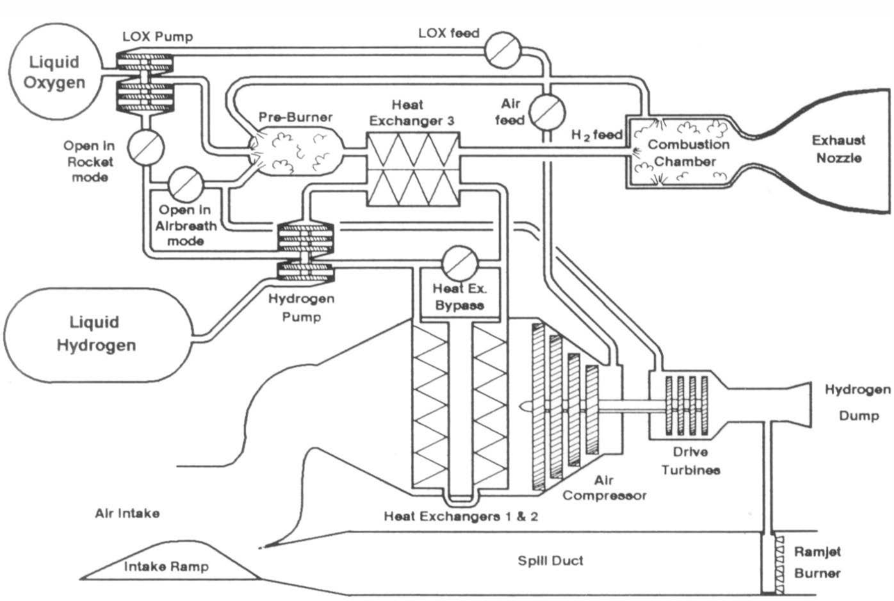


Fig. 1 Simplified flow diagram of the HOTOL RB545 engine.

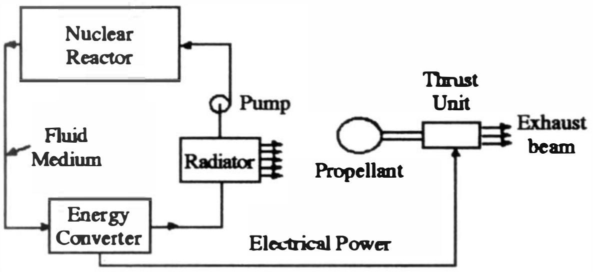


Fig. 3 Nuclear powered electric propulsion system.

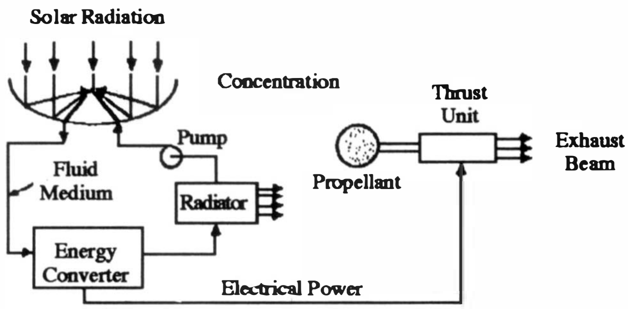


Fig. 4 Solar powered electric propulsion system.

gine thrust levels up to 200,000 lb (930kN) and a specific impulse of 8290 Ns/kg.

Applications of nuclear propulsion will be confined to orbital and outer space if the presently perceived hazard of radioactive release from such devices, whether normal or accidental, is found to prevail. In these circumstances chemical propulsion will remain the sole choice for lifting heavy payloads into orbit.

Electric Propulsion

Particles may also be accelerated to high velocities by the use of electrical energy. However, this requires that the rocket vehicle contain not only a thrust unit for accelerating the particles but also a plant to produce the electrical power. One type, using nuclear energy, is illustrated in Fig. 3.

A characteristic of electric propulsion systems is that with present technology the thrust levels are very low. This means that the vehicle will accelerate very slowly (typically 0.001 m/sec^2) as compared to 10 m/sec^2 for chemical and nuclear powered vehicles. The electrically powered vehicle must therefore accelerate for a long time, typically one month to one year, to reach its desired velocity.

In another type of electric propulsion, illustrated in Fig. 4, the power plant uses solar energy to generate electrical power. Radiators are required in both types of systems to reject the waste heat into space as a necessary by product of electricity generation.

There are three main methods by which the electrical energy may be converted into the kinetic energy of the particle jet:

- *The ArcJet Thruster*
  The propellant is heated in an electric arc and then expanded through a nozzle, as illustrated in Fig. 5. This is the simplest type of electric thrust unit. As with the nuclear rocket, hydrogen is usually the best propellant and may readily be heated substantially above 3000°K and an exhaust velocity of 15 km/sec should be obtainable without difficulty. However currently developed versions use hydrazine.

- *The Plasma Thruster*
  A gas may be heated to such a high temperature that it becomes a plasma, i.e. a mixture of ions and electrons in such proportions that there is no net electric charge. This plasma has a high electrical conductivity and may be accelerated by magnetic fields. Many types of plasma thrust unit have been studied. Fig. 6 shows one of the more promising devices, the "co-axial rail gun". A puff of gas (e.g. hydrogen, argon or nitrogen) is introduced between two concentric tubular electrodes, across which a condenser is discharged. The gas becomes ionized and radial currents flow in the plasma.
  The current along the central electrode produces a magnetic field as shown, which interacts with the radial current to give a force along the gun barrel, perpendicular to both the current and the magnetic field. In this way, the plasma may be accelerated to peak velocities of several hundreds of km/sec, although the mean velocity is lower (~ 50 km/sec). This process must be repeated many times per second to give a "continuous" thrust. So far plasma devices suffer from a low energy efficiency, usually less than 50%.

- *The Ion Thruster*
  In the ion thrust unit (Fig. 7), the propellant is ionised in an ion source, usually by bombardment with electrons, and accelerated to a high velocity (typically 40-100 km/sec) by a strong electric field. The total voltage drop is usually about one to a few kilovolts across a gap of a few millimetres. Electrons are injected into the beam from an elec-

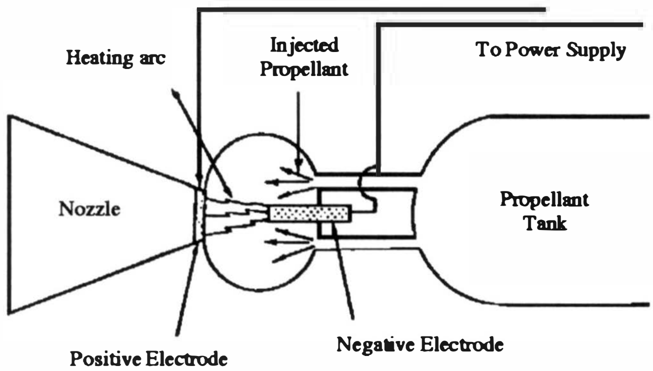
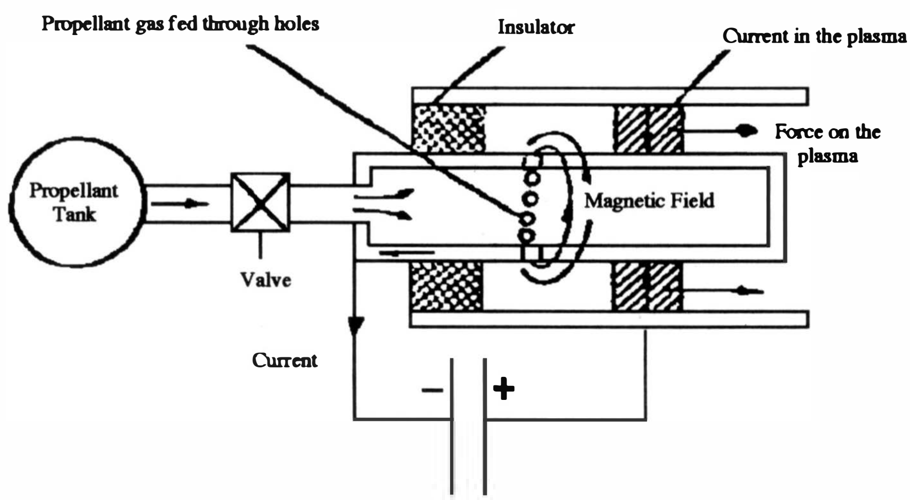
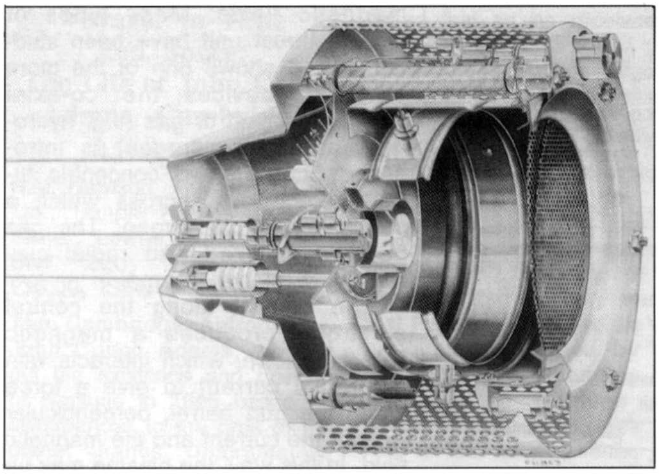


Fig. 5 Arc jet motor.

Fig. 6 Plasma rocket engine.





Artist's impression of a sectional view of the UK-10 ion propulsion system, (see *Spaceflight*, **October 1992, p.325).**
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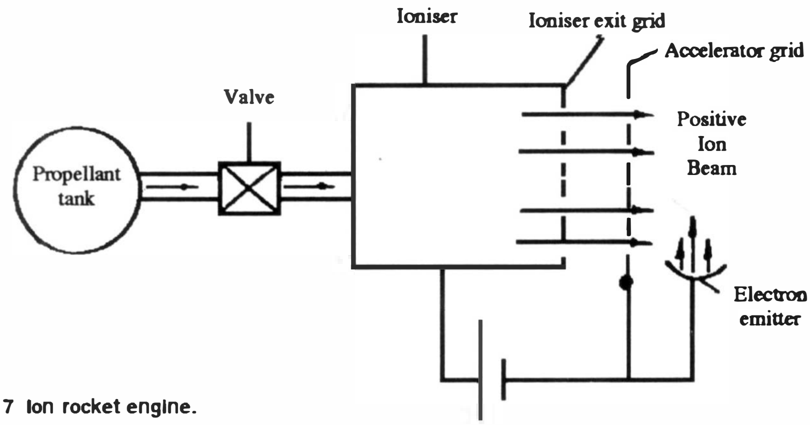


Fig. 7 Ion rocket engine.

tron emitter in order to keep it electrically neutral. The propellant is usually xenon, chosen for its high atomic mass and ionisation characteristics. The ion thruster has a high energy efficiency (70-80% at present).

All satellites, space probes and astronauts have been launched so far by chemical rockets because nuclear and electric propulsion systems are still in the development stage. Later, however, nuclear and electric rockets will become available for deep-space missions, i.e. missions from close Earth orbit to high satellite orbits, to the Moon and to the planets, for which high vehicle accelerations are not necessary. For example, an electrically-propelled vehicle could slowly spiral out from a close Earth orbit, eventually to place a communications satellite in a 24-hr orbit or to enter an interplanetary trajectory to Mars.

Electric propulsion usually promises higher payloads than chemical and nuclear-thermal propulsion for these missions. For launching satellites from the Earth's surface, however, or for landing on the Moon, much higher accelerations are required which only chemical and nuclear propulsion are able to offer. Table 1 shows the characteristics of typical chemical, nuclear and electrical rocket vehicles on missions for which they would be suitably applied.

This article has been compiled by L.J. Carter, BIS Special Projects Officer with the assistance of Fellows of the BIS from material prepared for publication as an Education booklet.

Table 1: Characteristics of typical rocket vehicles.

Propulsion	Two-Stage Chemical Rocket	Nuclear Rocket	Electric Rocket
Mission	Put a satellite into close Earth orbit	Earth orbit to Moon orbit and return	Earth orbit to Mars (impact or flyby)
Initial acceleration m/sec^2	13	3	0.001
Propulsion time	7.8 min	32 min	95.5 days
Total rocket mass tonnes	100	100	100
Propellant mass tonnes	87.6	67.3	26.0
Structure and propulsion system mass tonnes	9.7	10.5	23.4
Payload tonnes	2.7	22.2	50.6
Propellant exhaust velocity km/sec	2.6-4.2	8.5	32.5
Thrust	127-161 tonne force	29.4 tonne force	9.8 kg force
Electric Power	-	-	2270 kW

Some Useful Definitions

Ablation - The erosion of the surface of a solid body exposed to a high temperature gas stream moving with a high velocity. This happens in rocket nozzles during burning or when a spacecraft re-enters the Earth's atmosphere, and usually involves melting and/or charring the hotter parts of the vehicle.

Bipropellant - A liquid system that burns two propellants called the fuel and the oxidiser.

Boost - The extra power given to a rocket or space vehicle during lift-off, climb or flight, as with a booster rocket.

Characteristic velocity - **(1)** of a rocket vehicle: the increment of velocity which the vehicle would achieve by the consumption of its propellants in the absence of atmospheric drag and gravitational influence. This increment is equal to the natural logarithm of mass ratio times the effective exhaust velocity; **(2)** of a rocket combustion chamber: a parameter relating the combustion pressure to the mass flow per unit throat area, which is a measure of combustion performance.

Combustion chamber - The chamber in a rocket where the fuel and oxidant are ignited and burned. By common usage, the expansion nozzle is included as part of the combustion chamber, particularly for liquid-propellant engines.

Cryogenic propellant - A propellant which, at atmospheric pressure, has a boiling point below 0°C; liquified gas.

Exhaust velocity - The velocity of the exhaust gases (at the exit of a propulsion system). Measured in meters/second.

GEO - Geosynchronous Earth orbit.

GTO - Geosynchronous transfer orbit.

Hypergolic - A term describing two propellents which ignite spontaneously on contact with each other.

LEO - Low Earth orbit.

Mass ratio - The ratio of the all-up mass of a rocket to the mass when all the propellant has been consumed. The term can be applied to the complete vehicle, or to each stage of a multi-stage vehicle.

Monopropellant - A liquid-propellant system which employs one propellant (typically hydrazine).

Payload - The load carried in a vehicle in order to obtain the results for which the vehicle has been launched, e.g. for a satellite launching vehicle the payload is the satellite itself, whilst for the satellite the payload refers to its useful contents.

Specific impulse - The impulse (thrust x time) provided by burning a unit mass (or weight) of propellant. Measured in Newton-seconds per kilogram (or in seconds).

Static test - The firing of a rocket on a special test stand to measure thrust, etc.

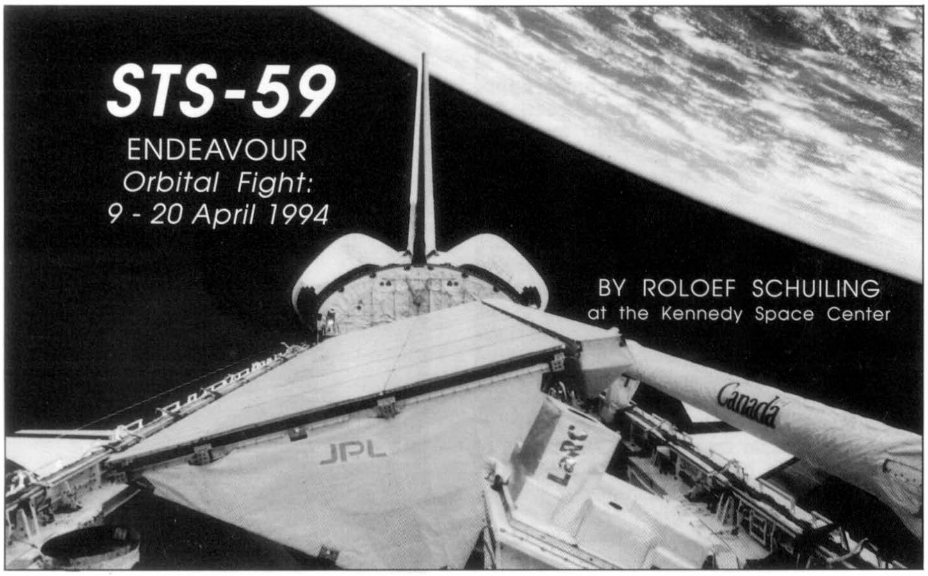
Thrust - The force created by the rocket motor. Measured in Newtons.

NOTES:

1 kg = 2.2046 lb approximately
1 tonne = 1000 kg and is a little less than one ton.
1 1bf = 4.448 Newtons

For Further Reading

Sutton, G.P., Rocket Propulsion Elements (16th Edn), Wiley, 1992.



The Space Radar Laboratory payload in the STS-59 cargo bay. This 70 mm frame photograph was taken through the aft flight deck windows of Endeavour. NASA

Endeavour Mission Heralds Space Radar Earth Study

With the launch of STS-60 on 3 February and STS-62 on 4 March, NASA's launch of Endeavour on 9 April was the third Space Shuttle mission launch in less than three months. The launch took place at 7:05 am EDT on 9 April after a one-day weather delay and was the 62nd launch of the Shuttle Program and the 6th launch of Endeavour.

Payloads

Following its successful role in the STS-61 Hubble Space Telescope Repair mission, Endeavour was rolled into the Orbiter Processing Facility's work bay number one where it spent the next 67 work days. The STS-61 payload configuration was removed, engine changes were made, and inspections and tests in preparation for the upcoming mission were accomplished.

The payload, which consisted of Space Radar Laboratory-1 and several Get Away Special (GAS) canisters was installed in the payload bay and Endeavour and its cargo were moved to the Vehicle Assembly Building on 14 March to be mated with the Solid Rocket Boosters and the External Tank. The move to Launch Pad 39A was made on 19 March.

Space Radar Laboratory-1 (SRL-1) is part of NASA's Mission to Planet Earth and is a dedicated Earth observation payload consisting of the Spaceborne Imaging Radar-C (SIR-C) and the X-band Synthetic Aperture Radar (X-SAR). The payload was described in ***Spaceflight***, May 1994, p.160 and is a joint project of the United States, Germany and Italy.

Also a part of SRL-1 was the Measurement of Air Pollution from Satellites (MAPS) instrument, the objectives of which are to measure the global distribution of carbon monoxide in the upper troposphere, to trace the transport of carbon monoxide between northern and southern hemispheres and, if possible, to determine if the sources are man-made or natural. The MAPS instrument has flown previously on Space Shuttle missions.

SIR-C/X-SAR made the cross-country trip from JPL to the Kennedy Space Center in July 1993. After assembly and testing it was moved to the Operations and Checkout Building where it was installed on a Spacelab programme cross-bay trusswork structure. In January 1994 the flight crew participated in a Cargo Integrated Test Equipment test to verify the readiness of SRL-1 and its electrical compatibility with the orbiter. After installation in the Endeavour an Interface Verification test validated the electronic and electrical connections with the orbiter and an End-to-End test verified SRL-1's compatibility with the NASA worldwide communications network.

STS-59 also included a number of secondary experiments; both in the payload bay and in the crew cabin. Crew cabin experiments located in the middeck area included the Space Tissue Loss/National Institute of Health-Cells experiment to study cell activity in microgravity and tissue loss due to pharmaceuticals; the Visual Function Tester-Four which measured the near and far points of clear vision and the ability to change focus; and the Shuttle Amateur Radio Experiment-II for two way communication between amateur radio operators on the ground and astronauts aboard the Shuttle.

Payload bay secondary experiments included GAS canisters with experiments involving the growth of crystals and thin films by vapour transport; the study of crystal-forming characteristics of water; the growth of slime moulds cultivated in microgravity; and the study of thermal conductivity with distilled water and silicone oils.

In addition to the interior experiments, Endeavour carried several improved thermal protective tiles mounted on the heat shield between the three main engines. The tiles, termed Toughened Unipiece Fibrous Insulation (TUFI) were developed to be more resistant to damage than the current orbiter tiles. If the test flights of TUFI prove successful, they may be used to replace tiles in areas which receive impact damage such as the heat shield between the engines, near landing gear doors and near thruster engines.

Mission Specialist Thomas D. Jones (left), astronaut Andy Thomas and Payload Commander Linda Godwin examine SRL-1 in the Operations and Checkout Building in January 1994. NASA

Countdown

Following the Shuttle's arrival at Launch Pad 39A, the launch count was picked up at 11:00 am on 4 April 1994 and contained 26 hours and 7 minutes of built-in-holds with T-0 at 8:07 am on 7 April.

During this period, however, engineers inspecting a Space Shuttle Main Engine turbopump in California found that the radius on one of the vanes that directs the flow of liquid oxygen through the preburner area was smaller than required. Although the pumps on Endeavour's engines had passed required proof testing and dye penetrant inspections prior to being installed, NASA managers elected to hold the countdown and inspect the turbopumps on Endeavour by using a borescope to look inside the units. This did not require removing the engines; however, the countdown was held at the T-27 built-in-hold for an additional 24 hours longer than initially planned to accomplish the inspection and the planned T-0 moved from 7 April to 8 April.

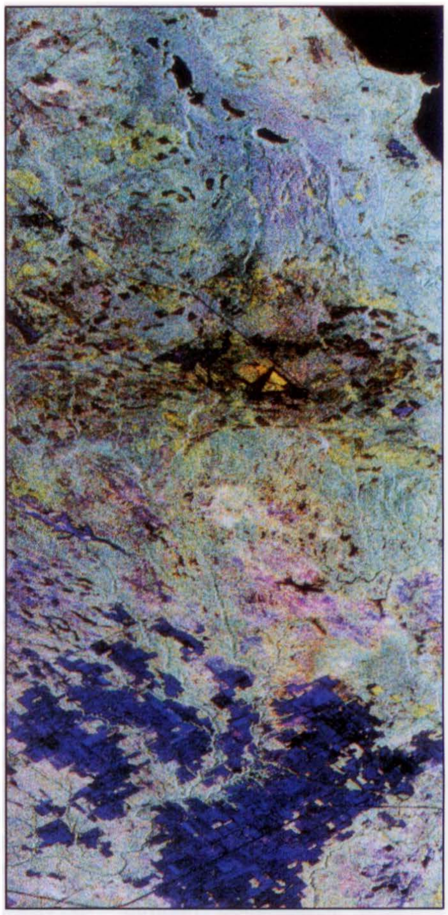
The countdown went well but in the early morning hours of the 8th an approaching

weather system threatened the planned launch time. As the countdown approached the T-9 minute built-in-hold the decision was made to remain in the hold beyond the planned 10 minutes in order to allow the team to monitor the weather situation. At that point the major concern was cloud cover below the acceptable limit for a Return To Launch Site (RTLS) abort. The restriction on cloud cover for an RTLS situation is 5-tenths of cloud cover or greater at or below 8,000 feet.

Cloud cover projections were for "bands" of the weather system to be passing over the KSC area and it was hoped that by holding at T-9 minutes the team could react to an improvement in the weather situation rapidly and conduct the final countdown operations and launch. The launch "window" - the period during which a launch was possible - was dictated by flight crew fatigue and set at two and a half hours beyond the planned T-0. This is based on the time that the flight crew remain on their backs after entering their seats in Endeavour's cabin. The STS-59 window lasted from 8:07 to 10:37 am and the nature of the weather system made it likely that a period of less cloud cover might develop.

As the end of the launch window approached it became apparent that the cloud cover was dissipating and the countdown was resumed and taken to T-5 minutes and holding. T-5 minutes is the last point before Auxiliary Propulsion Units start and the last point before liquid oxygen drainback temperatures become a factor. Once past T-5 minutes the hold capability of the Shuttle is very limited. At T-5 minutes the launch team could gauge between the approach of the clear weather and the end of the launch window and would be able to time the launch attempt more precisely.

As the cloud cover dissipated, however, the now-clear air developed increasing winds. The winds violated the



Right: **A false-colour composite image of Raco, Michigan produced using both L-band and C-band data. Raco is located at the eastern end of Michigan's upper peninsula at the boundary between the boreal forests and the northern temperate forests, a transitional zone that is expected to be ecologically sensitive to anticipated global changes resulting from climatic warming.**

In this colour representation (red = LHH, green = LHV, blue = CHH), darker areas in the image are smooth surfaces such as frozen lakes and other non-forested areas. The colours are related to the types of trees and the brightness is related to the amount of plant (forest biomass) material covering the surface. The black area in the upper right corner is ice-covered Lake Superior. The blue mosaic areas in the lower part of the image are bare agricultural fields with hay stubble. The shore line of Lake Superior in the light greenish blue is a mixture of aspen and birch trees. South of that is a dark purple area containing north hardwoods.

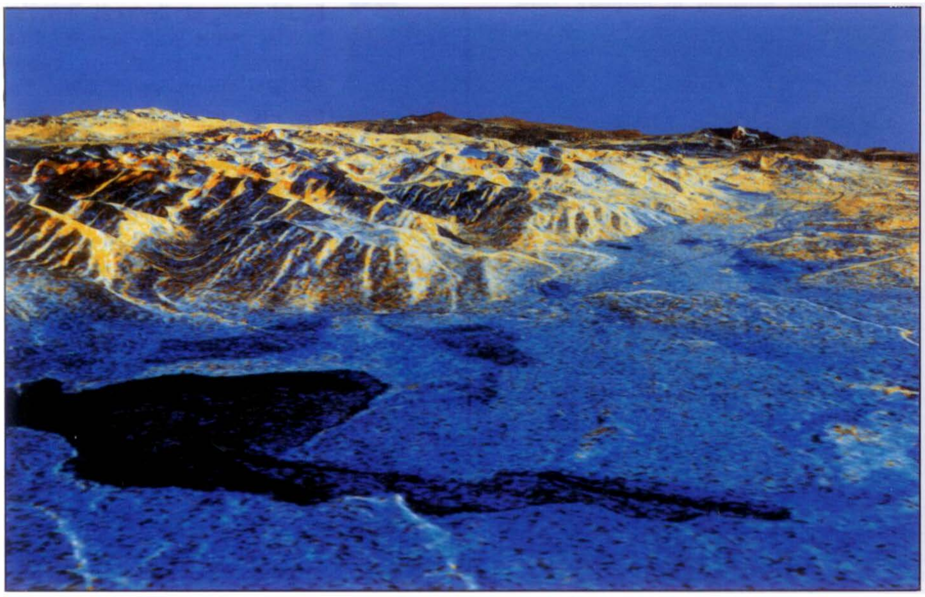
Accurate information about land-cover is important to area resource managers and for use in regional- to global-scale scientific models used to understand global change. **JPL**

cross-wind restrictions for a RTLS. Although the flight crew volunteered to remain in their seats longer in the hope of lower winds leading to a launch, the weather predictions did not indicate any reduction of wind speed in the next half hour or so. The lack of any indication of wind reduction, together with the fact that the next day's launch opportunity was only a little more than twenty hours away, led to the decision to scrub the 8 April launch attempt and recycle for the following day.

After the pad and Shuttle were placed in a safe condition the flight crew left Endeavour and returned to their quarters. The countdown clock was recycled to T-11 hours and holding. The propellants were drained out of the orbiter and recycle

A three-dimensional perspective of Mammoth Mountain, California constructed by overlaying a Spaceborne Imaging Radar-C (SIR-C) radar image on a US Geological Survey digital elevation map. The vertical exaggeration is 2 times.

In this colour representation, red is C-band HV-polarisation, green is C-band VV-polarisation and blue is the ratio of C-band VV to C-band HV. Blue areas are smooth, and yellow areas are rock outcrops with varying amounts of snow and vegetation. Mammoth Mountain is shown in the upper right. **JPL**



contingency plans were in operation.

At 5:45 pm on the 8th, the countdown was restarted at T-11 hours. The External Tank propellant load began at about 10:45 pm and the astronauts left their quarters shortly before 4:00 am on the 9th to reboard Endeavour. The remainder of the countdown went well and as dawn approached on the 9th the skies above the launch area were clear and the winds were acceptable. The terminal countdown proceeded out of the last built-in-hold at T-9 minutes and proceeded to T-0 with no problems. At 7:05 am Endeavour lifted off the launch pad to begin its STS-59 mission, arcing toward the North East on its climb to the 57 degree orbit. SRB staging was normal and came at launch plus two minutes and five seconds. The main engines performed satisfactorily and engine shutdown came at launch plus eight minutes and thirty-four seconds.

Mission Operations Day-by-Day

Flight Day One

Following their arrival on orbit, at an altitude of 120 to 121 nautical miles, the STS-59 crew began preparing Endeavour for mission operations which began at about two and a quarter hours into the flight with activation of Space Radar Laboratory-1 (SRL-1). The mission was a 24-hour per day mission for the crew and to cover their many activities they were divided into two teams - Red and Blue - which would alternate work and sleep periods. At three and a half hours into the mission the Blue team of Mission Specialists Jay Apt, Michael Clifford and Thomas

Jones began their first sleep period. The Red team consisted of Mission Commander Sidney Gutierrez, Pilot Kevin Chilton and Payload Commander Linda Godwin.

Ground controllers made a detailed checkout of the Space Radar Laboratory and then data collection began. The SIR-C instrument was working well.

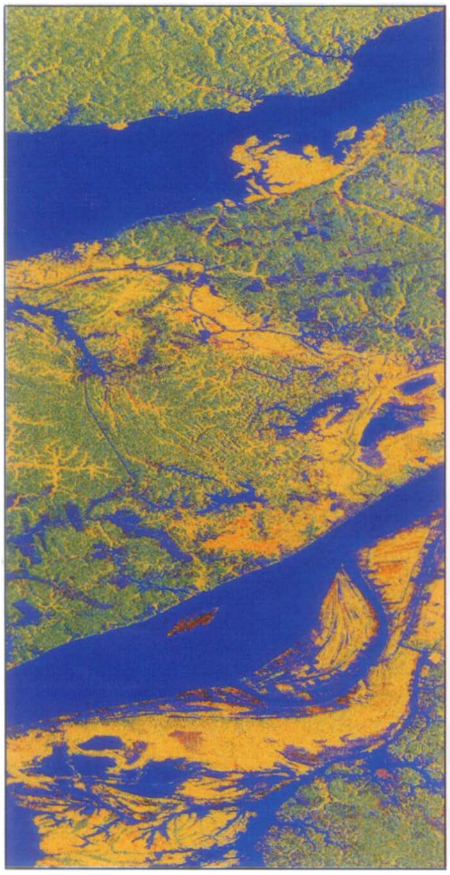
Those working with the X-SAR instrument, however reported a problem in activating the high power amplifier which provided power to the X-SAR antenna system. Trouble-shooting led to the discovery of a fault in an undervoltage sensor circuit internal to the amplifier. After about three hours the ground team was able to develop a procedure to bypass the faulty circuit and the X-SAR instrument was soon operational. Meanwhile, the MAPS (Measurement of Air Pollution from Satellites) instrument began detecting carbon monoxide in the Earth's atmosphere.

A 16 mm lens on a 35 mm camera provides this unusual wide-angle view of Endeavour's flight deck during a mission STS-59 checkout of the flight control systems. **NASA**

Flight Day Two

Already the radar laboratory had taken data readings on more than 40 targets, including Howland, Maine; Macquarie Island; the Black Sea; Matera, Italy; and the Straits of Gibraltar.

Radar data had also been gathered on many of the 19 "supersites" which were the highest priority targets. Supersites under study for hydrological and geological observations included Duke Forest, North Carolina; Ötztal, Austria; Lake Chad in the Sahara; Gippsland Island, Australia; Sable Island; Toronto, Canada; Bermuda; Bighorn Basin, Wyoming; Chung Li, China; Mammouth Mountain, California; Raco, Michigan; and the Gulf Stream for oceanographic observations.



Flight Day Three

Among real-time radar images downlinked from Endeavour overnight was a view of the Sahara Desert in Algeria. The SIR-C and X-SAR radars can penetrate the Sahara's dry sand cover to reveal centuries-old drainage patterns.

Another area studied by ground quick-look image processors was the ocean around Japan where oil slicks were noted. Scientists from a Tokyo research laboratory are working with an oceanographer for Hamburg, Germany to interpret the radar images. Of particular interest to them was a region where cold and warm ocean currents meet.

Students from the University of Munich participated in a concurrent ecology project in which they made ground measurements of soil moisture, forestry parameters, and the biomass of agricultural crops in the area at the same time as the radar laboratory gathered data for comparison purposes.

The day's radar work also included passes over Palm Valley, Australia and the Amazon Basin forests of Brazil. Oceanographic studies were made of the Pacific Ocean, the Gulf of Mexico and the Gulf Stream.

Linda Godwin reported good photography of thunderstorms over South America and ocean wind patterns as the crew continued to complement the radar images with photographic studies. She also reported making SAREX-II short wave radio contacts with students and Boy Scouts in Michigan, California and Texas.

Left: **This false-colour L-band image of the Manaus region of Brazil shows the Solimoes and Rio Negro rivers just before they combine at Manaus to form the Amazon River.**

Red areas correspond to high backscatter at HH polarisation, while green areas exhibit high backscatter at HV polarisation. Blue areas show low returns at VV polarisation; hence the bright blue colours of the smooth river surfaces. Using this colouring scheme, green areas in the image are heavily forested, while blue areas are either cleared forest or open water. The yellow and red areas are flooded forest. **JPL**

Tom Jones gave scientists real-time observations of thunderstorms over Taiwan, the Philippines and New Guinea to augment data being collected by the MAPS instrument. The MAPS ground science team reported a good correlation between what the MAPS instrument was reading compared to data gathered on the ground. The MAPS instrument had collected over 38 hours of data on air pollution by this point and had mapped nearly half of the Earth's carbon monoxide.

Flight Day Four

During the Blue team shift, a real-time image was downlinked from the X-SAR radar which showed a region of the Andes mountains in Bolivia. Scientists hope to learn more about the topography and climate of the Central Andes, including the plate tectonics of crustal movement and climate-induced erosion such as mud slides.

Jay Apt reported a large thunderstorm area over the Central Pacific as Tom Jones commented on the largest lightning storm system seen so far on the mission. The storm system covered a large area of Western Africa. Blue shift members also reported good Earth photography of Chinese locations in support of radar observations.

During the Red team shift, real-time X-SAR images of the area around Sarobetsu, Japan were downlinked. This area was one of the high-priority areas for study and scientists on the ground measured the strength of the radar signal and the size of the swath being imaged.

Observations were also made of the Bay of Campeche in Mexico by X-SAR as ground personnel made simultaneous measurements at the ecological test site. The studies of soil and vegetation in the area during the current dry season will be compared later with observations during the wet season during the SRL-2 STS-68 flight in August. Endeavour's crew were asked to make photographic documentation of weather and human disturbances in the area such as fires, storm damage and clearance cutting.

Kevin P. Chilton and Linda M. Godwin monitor and photograph cloud patterns from Endeavour's aft deck during mission STS-59. NASA

Flight Day Five

Overnight, researchers watched televised downlinks of X-SAR images of surface and subsurface structure in the Namib Desert in South Africa during studies of radar backscatter. Scientists studied images of sea ice and seasonal melt in the Sea of Okhstok off the coast of Siberia and also studied a critical region of expanding drought in Sudan.

As Endeavour passed over Australia, Jay Apt exchanged greetings with the Russian cosmonauts aboard the Mir space station, then about 1200 nautical miles distant. Both crews used amateur radio equipment for the contact which was monitored by many amateur radio operators.

The SIR-C and X-SAR radar instruments continued with their observations; having already filled almost one half of the data recording tapes.

Flight Day Six

Six minutes of real-time radar images were sent down as Endeavour flew across Europe. The Ötztal area in the Austrian Alps is an hydrology supersite which is important to scientists studying how snow cover influences runoff in the area and the amount of water available to surrounding regions from the melting snow. The radar images will also be compared to previous images from aircraft overflying the area.

The X-SAR and SIR-C instruments supported ecological studies of Russia, Uganda and Siberia; oceanographic studies of the Australian Coast, Gulf Stream and North Atlantic; water cycle studies of California, Oklahoma and Brazil; and geological studies of Chile, China and Mount Pinatubo in the Philippines.

The Blue team reported good photography of a gigantic fire-scarred area which burned in 1987 in China. The area is of special interest to the MAPS group's studies of forest regrowth after a fire.

In addition to the planned radar observations, SRL-1 was able to include a number of unplanned areas for observation including flood areas in Missouri and Germany. Flood areas in Columbia were also being studied as part of the mission's water drainage pattern investigations. A tropical cyclone in the Pacific and the San Andreas fault area of the Western United States were observed as well. These observations were recorded on tape aboard Endeavour for analysis after the mission.

Other observations included Hawaii, Australia, Wyoming, the Galapagos Islands and California. X-SAR images of California were downlinked to scientists as part of the studies on snow melt and drainage. Quick-look processing of downlinked images also provided data on soil moisture fluctuation in the Oklahoma-Texas region and a team of Ninnekah Oklahoma High School students conducted ground measurements to determine how far beneath the surface the radar was measuring the soil moisture.

Flight Day Seven

Calibrations of the radar instruments were made over Germany as students took simultaneous biomass and soil moisture measurements. Although the vast majority of the data was being stored on tape aboard Endeavour, views made with all three radar frequencies of volcanoes at Mount Pinatubo in the Philippines and Mount Kilauea in Hawaii were downlinked.

Crewmembers continued taking photographs to supplement radar views and were estimated to have taken over 14,000 views by the end of the flight.

Flight Day Eight

As the SRL-1 instruments continued their programmes of observation, Jay Apt used the SAREX-II amateur radio equipment to talk to fellow astronauts Norm Thagard and Bonnie Dunbar, together with Russian cosmonauts, at the Star City training centre outside Moscow. The two American astronauts are in training at the Star City site for a US-Russian mission aboard the Mir space station in 1995.

The crew sent down a preliminary composite map of the carbon monoxide distribution in the Earth's atmosphere derived from measurements with the MAPS instrument.

Although the majority of the radar data was stored on tapes aboard Endeavour for later ground processing, some intriguing views are sent down to Earth. One view showed a composite map of the Sahara Desert and should help to understand what the area looked like in ancient times and how once-productive areas became desert.

Flight Day Nine

During the Blue team's activity the SRL-1 made geological observations of Chile, Bolivia and Bangladesh; ecology images of France, Siberia and Mexico; oceanographic studies over the North Sea and Equatorial Pacific; and took calibration data over Italy and Germany.

After the handover from the Blue team to the Red team at about 9:35 am Endeavour's flight control surfaces and thruster jets were checked out in preparation for the planned landing on 19 April.

Crewmembers held their traditional in-flight news conference and answered questions dealing with the significance of the mission.

Flight Day Ten

As engineers on the ground had been receiving a "tape threading fault" message from recorder number one that indicated it was not working optimally, payload controllers at Houston decided to record data gathered by the SIR-C instrument on recorder number two aboard Endeavour. Until then controllers on the ground had been toggling between the two recorders for SIR-C data; however SRL-1 managers decided to use only recorder number two for the remainder of the flight to protect all remaining SIR-C data takes. The X-SAR radar used a third recorder aboard Endeavour and was not affected.

Radar images were made overnight of geology sites in Tunisia, Chile and Saudia Arabia as well as oceanography sites in the North Sea, Gulf of Mexico and around the Norfolk Island area.

Commander Gutierrez and Pilot Chilton performed a standard landing-minus-one-day checkout of Endeavour's systems. Stowage operations were also done in preparation for the then-planned landing on the 19th and they also cali-

About the Crew

The STS-59 flight crew was made up of six astronauts divided into two shifts - termed red shift and blue shift - to cover the 24 hour per day flight operations.

The Mission Commander was ***Sidney M. Gutierrez***, 42, Col., USAF, who was selected to be an astronaut in 1984 and had previously flown 218 hours in space as Pilot on the STS-40 mission of Columbia in June 1991.

Also making his second space flight was Pilot ***Kevin P. Chilton***, 39 Col., USAF, who was selected to be an astronaut in 1988 and flew more than 213 hours in space on Endeavour's maiden flight of STS-49 in May 1992.

Payload Commander and Mission Specialist-Three was ***Linda M. Godwin*** (PhD), 41, who became an astronaut in 1986. STS-59 was her second space flight as she flew as Mission Specialist on the STS-37 mission of Atlantis in April 1991. She has over 143 hours of space flight time.

Mission Specialist-One was ***Jay Apt*** (PhD), 44, who qualified as an astronaut in 1986. This was his third space flight as he had previously flown on the STS-37 mission, as well as Endeavour's STS-47 mission in September 1992. He has over 334 hours of Space Shuttle flight experience including 10 hours and 45 minutes on two EVAs.

Mission Specialist-Two was ***Michael R. Clifford***, 41, Lt. Col., USA, who was making his second space flight. He was selected as an astronaut in 1990 and flew as Mission Specialist on the STS-53 mission of Discovery in December 1992. He has over 175 hours of space flight.

Mission Specialist-Four was ***Thomas D. Jones*** (PhD), 39, who was making his first space flight on STS-59. He qualified as an astronaut in 1991.

SATELLITE DIGEST-267

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
USA 103	1994-026A	May 3.66	ER	Titan-4/ Centaur	8,000 ?	No orbital data issued					[1]
SROSS C2	1994-027A	May 4.00	Sriharikota	ASLV	113	May 4.25	46.03	98.30	433	922	[2]
MSTI 2	1994-028A	May 9.12	WR	Scout G-1	117	May 10.64	96.94	92.61	357	448	[3]
STEP 2/P91-A	1994-029A	May 19.71	EAFB	B-52/Pegasus	180	May 19.89	81.96	99.02	603	821	[4]
Gorizont 30	1994-030A	May 20.08	Tyuratam	Proton-4	2,125 ?	May 29.27	1.33	1,435.76	35,773	35,787	[5]
Progress-M 23	1994-031A	May 22.14	Tyuratam	Soyuz	7,250 ?	May 24.37	51.65	92.53	398	400	[6]
Cosmos	None	May 25.30	Plesetsk	Tsyklon	2,000 ?	Failed to reach orbit					[7]

NOTES

1. Classified payload, launched for the US Department of Defense: payload is believed to be a SIGINT satellite, possibly in the Advanced Jumpseat series similar to the shuttle-deployed satellites 1989-061B (USA 40 deployed from STS-28R) and 1992-086B (USA 89 deployed from STS-53). No orbital data for the mission were released, but the satellite might be in a Molniya-type orbit.
2. Second successful launch of a SROSS (Stretched Rohini Satellite Series) in four launches: satellite carries two payloads: a Gamma Ray Burst experiment for astronomical observations and a Retarding Potential Analyser to investigate the characteristics of the equatorial and low-latitude ionosphere and thermosphere.
3. Second launch of a MSTI (Miniature Seeker Technology Integration) satellite. Carries a platinum-silicide camera and an indium-antimonide instrument with six filters using a gimballed mirror which will allow the tracking of fixed targets and ballistic missiles. Final flight of the Scout launch vehicle.
4. STEP 2 (Space Test Experiment Platform) carries the SIDEX (Signal Identification Experiment) and was planned to work with TEX (1990-031B) and REX (1991-045A) satellites. Deployment was planned for a circular 835 km orbit, but an eccentric orbit reaching out to the circular orbit altitude was reached instead.
5. Communications satellite, referred to as "Gorizont-42" in some Russian literature: also known as RIMSAT 2. Like Gorizont 29, the satellite was immediately leased to the RIMSAT Corporation in the USA after launch, with deployment planned over 142.5 °E.
6. Unmanned cargo freighter, which docked with the Mir Complex May 24.25. Carrying 2,207 kg of supplies plus a recoverable Raduga capsule.
7. On May 25 ITAR-TASS announced that the intended Cosmos 2281 satellite had been launched from Plesetsk that day at 11.15 Moscow Time (07.15 GMT). The second and third stages of the three-stage Tsyklon launch vehicle had failed to separate since the command for separation had not been received (possibly due to a fault in the satellite's control system), and the assembly comprising the second and third stages and the satellite impacted off the eastern coast of Siberia. No details of the payload have been released, although some western reports have suggested that it was a Worldwide ELINT payload, in which case the planned orbit would have been 82.5°, 97.7 minutes, 635-670 km. The launch time suggests that the orbital plane would have been 30° to the east of Cosmos 2242 (1993-024A), the previous launch in the series.

ADDITIONS AND UPDATES

1990-091B Galaxy 6 was manoeuvred off-station over 257 °E approximately May 4 and by May 13 the satellite had been re-located over 285-286 °E.

1993-066A INTELSAT 701 was re-located over 173-174 °E during mid-March.

1994-002A Gals 1 was manoeuvred off-station over 43-44 °E approximately May 25: the satellite was still drifting to the east at the end of the month.

1994-018A Cosmos 2274 was de-orbited with its main re-entry module being recovered approximately May 21.8.

1994-019A Progress-M 22 undocked from the Mir Complex 1994 May 23.04 and was de-orbited later the same day.

1994-022A Add the following orbital data for GOES 8: May 11.67, 0.44°, 1,435.89 minutes, 35,634 km, 35,931 km.

brated the "heads up" display they use for the landing.

Meanwhile, the radar laboratory instruments took advantage of the one day's flight extension due to abundant supplies; and made unplanned images of glaciers and flooding areas. The SRL-1 instruments were then switched from their primary to backup electronics package. The primary system worked flawlessly throughout the flight, however managers wished to verify that the backup systems were also working perfectly. In preparation for the planned landing, the X-SAR instrument was deactivated at 8:15 pm.

Flight Day 11

The SIR-C continued observations until just after 1:00 am when it was powered off in preparation for the scheduled landing. Following deactivation of the SRL-1 instruments, payload managers reported that over 70 million square kilometres of the Earth's surface had been imaged on the flight. This represented about 12 per cent of the Earth's total surface. About 25 per cent of the Earth's total land area had been covered.

There were two landing opportunities at the Kennedy Space Center on 19 April. One of these was at 11:52 am and one at 1:23 pm. The weather, however, did not cooperate and the landing was cancelled for the 19th due to cloud cover and high winds in the vicinity of the runway.

Following the cancellation of the landing, the crew of Endeavour reconfigured the spacecraft for orbital operations. The payload bay doors were reopened and, per contingency planning, the SIR-C radar instrument was reactivated to take advantage of the opportunity for another series of radar imagings.

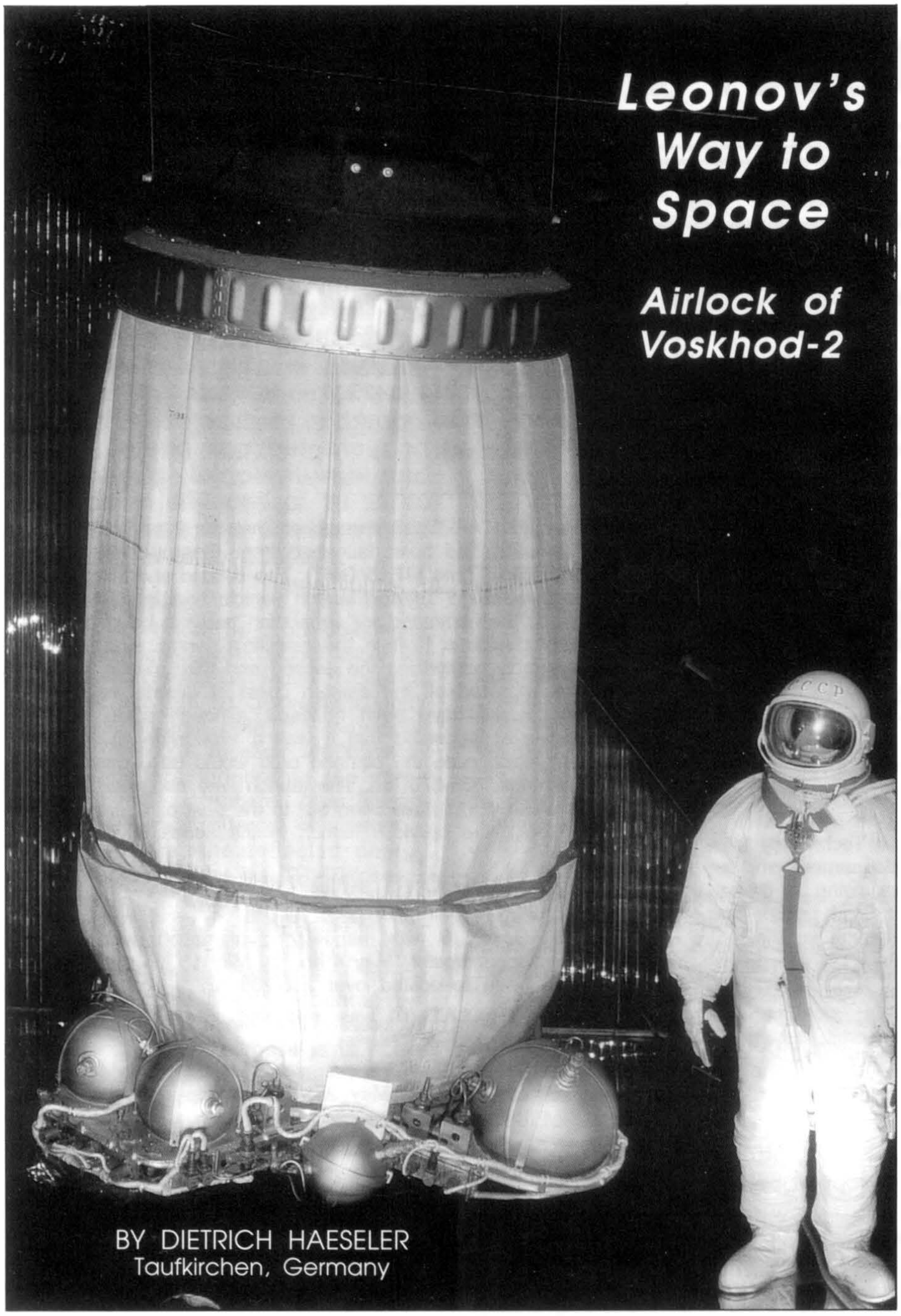
Flight Day Twelve

Crewmembers again readied their spacecraft for landing and the orbiter's payload bay doors were closed at 8:00 am.

There were two landing opportunities at both Kennedy Space Center and at the Edwards Air Force Base on the 20th. The weather at the Kennedy landing facility did not improve and flight controllers decided to bring Endeavour down at the California site.

The landing in California came at 12:54 pm on 20 April and brought to a close the 11 day, 5 hour and 49 minute mission. The flight had covered over 4.7 million statute miles in 183 orbits. Endeavour made a record-breaking 412 manoeuvres while in orbit.

The SRL-1 instruments recorded at total of 133 hours of data on 165 data tapes. Of the total 38.5 million square miles mapped by the instruments, the SIR-C mapped 25 million square miles and recorded 90 hours of data and the X-SAR mapped 18.5 million square miles and recorded 43 hours of data. The SIR-C and X-SAR instruments will fly again on Endeavour's next mission which is STS-68. ■



Leonov's Way to Space

Airlock of Voskhod-2

BY DIETRICH HAESELER
Taufkirchen, Germany

Left: **A reserve airlock manufactured for the Voskhod 2 mission that is now exhibited in the Cosmonautics Memorial Museum in Moscow. The lower ring with the four pressure air and oxygen tanks can be seen as well as a space suit like the one used by Leonov.**

ALL PHOTOS SUPPLIED BY THE AUTHOR

Almost thirty years ago, during the so-called space race, both the USA and the Soviet Union aimed at being the first "to land a man on the Moon and return him safely to the Earth" in the words of the goal set by President J.F. Kennedy. New technologies and capabilities had to be mastered, one of the most important of which was to learn how astronauts and cosmonauts could work outside of their spacecraft.

The USA had publicly announced the Gemini programme during which extravehicular activities (EVAs) would be performed. The whole pressurised cabin of Gemini was used as an airlock; it was depressurised, one of the hatches was opened and, after the EVA astronaut had returned to his seat, the cabin was repressurised again.

But the Soviets were the first to perform an EVA after making preparations with great secrecy. Voskhod-2 was launched into Earth orbit, where Alexei Leonov performed the first EVA, while the commander, Pavel Belyayev, remained inside the cabin. The history of the Voskhod programme and of the first EVA has already been well reported, [1,2]; but not much information has been given about the airlock system itself. Information from various sources and a study of the available airlock units that are museum exhibits reveal how an interesting technological solution was found for creating an airlock.

The Soviets were very ingenious in circumventing the restrictions imposed on the Voskhod spacecraft design as a result of it being a hastily arranged modification of the Vostok spacecraft in order that an EVA could be performed before the new Soyuz became operational. An airlock was necessary because the on-board systems in the Voskhod Descent Module (DM) were not designed to work *in vacuo*. The airlock could be positioned only at the sides of the DM, as the top was already occupied by the reserve retrorocket package, while the bottom was attached to the Instrument Module. The airlock assembly also had to fit into this side position under the aerodynamic shroud of the launch vehicle.

A solution was found by making the airlock collapsible to be flat enough to fit under the shroud during launch and after deployment to inflate to give sufficient room for the EVA-cosmonaut in a space suit to operate the two hatches on both ends of the airlock.

The design of the airlock is shown in the diagram opposite. The lower ring was attached to the DM, while the upper ring carried the exit hatch to space. Both rings were rigid and had an outer diameter of 1.2 m. They were connected by a double-walled hermetical flexible cylinder made from rubber material. The space between the outer and inner walls of the soft cylinder was divided into 40 inflatable partitions called aerobooms ("aerobalky"), which were pressurised with air to 0.65 bar in three independent sections. For redundancy two sections were sufficient to deploy the airlock. As long as the airlock was pressurised on the inside, the pressure difference to the ambient vacuum would have probably been sufficient to keep the cylindrical shape of 2.5 m length and 1 m internal diameter. However, when the outer hatch was opened towards space this pressure difference would disappear and the airlock would lose its shape without the aerobooms and it would be extremely difficult for the cosmonaut to enter the airlock again and close the hatch to allow repressurisation.*

The airlock was covered by a protective pressure-fabric envelope on its outside which also served as thermal insulation to regulate the temperature. Handrails were integrally machined to the outer circumference of the upper ring around the exit hatch. The airlock could be folded to a length of 0.7 m under the launcher shroud and, using the aeroboom system, could be deployed in space to a total length of 2.5 m, resulting in an inner

* The aerobooms carried the upper ring over the lower ring, thus stretching the skin to cylindrical shape.

volume of approximately 2.5 cubic metres.

Two 16 mm filmcameras were mounted inside the airlock to record the cosmonaut's egress and ingress, illumination being provided by two lights. A third camera was attached to a short boom outward of the upper ring to film the cosmonaut's movements in front of the exit hatch. The cosmonaut's distance from the airlock was limited by a 5.35 m long safety tether. In addition, a TV-camera provided live coverage of the event to the ground control centre and the commander inside Voskhod 2 could view the same TV-images on a special monitor. He wore an EVA space suit to be able to rescue his colleague if problems arose [4].

The airlock system was controlled by the commander from inside the spacecraft. However, a duplicate set of the controls were contained in a small box inside the airlock. This control panel was suspended on four bungee-cords, connected in pairs to the lower and upper ring. As long as the airlock was folded the panel was secured to the upper rings. When the airlock was deployed the bungee-cords were set under slight tension and supported the control panel about midway in the airlock within the reach of the cosmonaut. The controls on this panel include eight switches to control the operation of both hatches, the depressurisation and filling of the airlock, and the associated valves. Analogue displays showed:

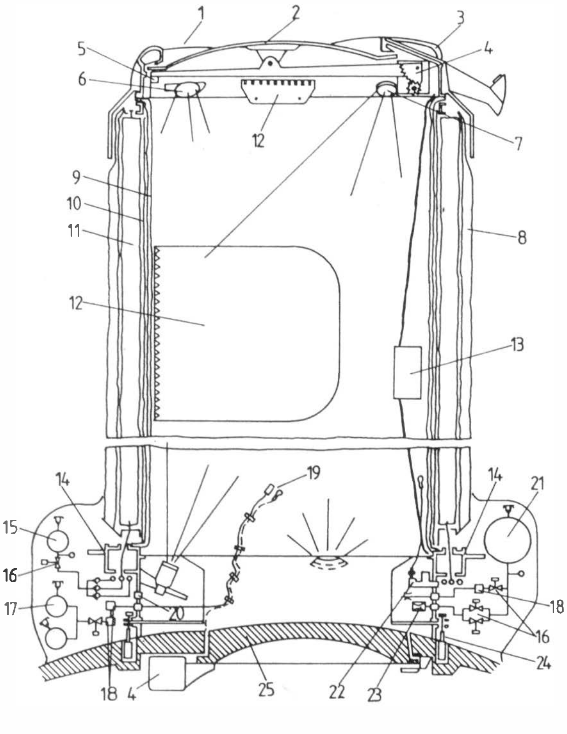
- pressure inside the airlock, from 0 to 0.8 atm
- oxygen tank pressure, from 0 to 200 atm
- airboom air supply pressure tank, from 0 to 200 atm.

A metal grill covered the control panel to prevent any unintentional movement of the switches by the cosmonaut in his bulky spacesuit.

Both hatches had a diameter of 0.65 m, which was nearly too small for the cosmonaut to slip through. When he wanted to re-enter the airlock Leonov experienced severe problems because his suit had inflated like a balloon. The hatches are both driven electrically, but manual operation was possible using a rotating knob for the drive and a larger grip to tighten the hermetical seal. Both hatches were arranged off-centre of the airlock cylinder, being displaced opposite to the airlock control panel. This kept the cosmonaut at some distance from the panel, allowing easier movement and better manipulation of the controls but, with an internal diameter of only one metre, the airlock was still very small for accommodating movements of the cosmonaut. On seeing the inside of an airlock mock-up it was hard to imagine how Leonov succeeded in turning his whole body around upside down wearing his bulky inflated space suit.

Four spherical tanks are mounted around the lower ring. One large tank supplied the air to repressurise the airlock and one small tank pressurised the aerobooms with air, a process that took seven minutes. Two medium-sized tanks provided reserve oxygen through a safety tether to the cosmonaut's space suit. The space suit contained enough oxygen for 45 minutes, while the airlock supplies lasted for another 80 minutes [5].

The airlock was fixed to the outside of the Voskhod DM by bolting the lower airlock ring flange around the exit hatch of the DM. Pyrocharges were used to separate the airlock after use from Voskhod. If the airlock could not be separated it would uncontrollably burn up during atmospheric reentry, thus posing a potential hazard. In addition, keeping more than the DM flange of the airlock at the outside of the DM would probably change the

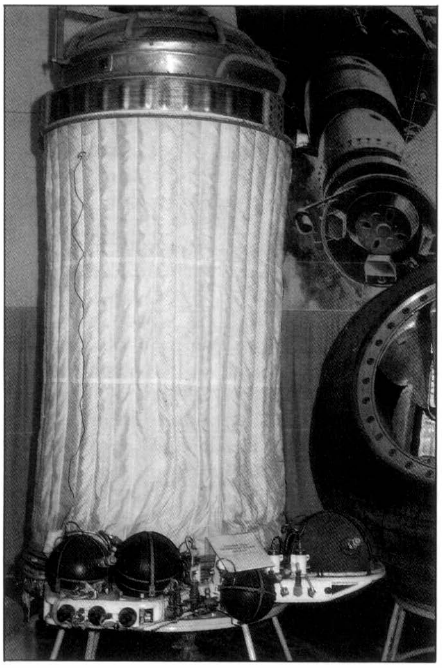


Flexible airlock of Voskhod-2 (adapted from ref. 3).

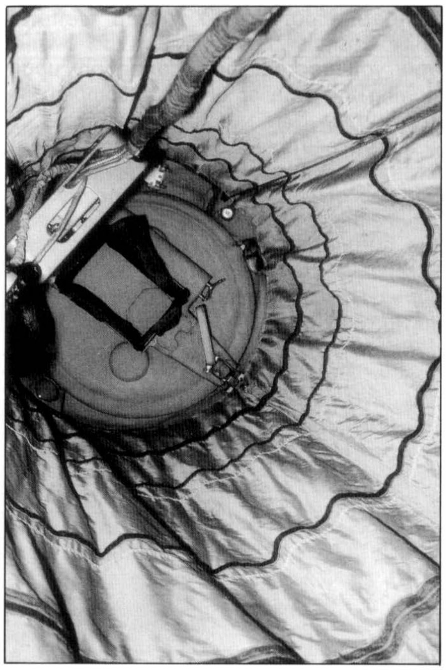
KEY

1. upper end of the airlock
2. exit hatch to open space
3. handrail
4. hatch drive
5. closing mechanism of the hatch
6. light
7. film camera
8. soft part of the airlock
9. hermetical liner
10. protecting cover
11. [air-pressurised] airboom
12. airlock equipment fixation elements when collapsed
13. control panel
14. rigid flange
15. filling system of the airbooms
16. electro-pneumatic valves
17. system for supplementary oxygen provision
18. [pressure] reducer
19. safety tether with oxygen hose
20. safety valve
21. airlock depressurisation and filling system
22. pressure relief valve
23. filling valve
24. airlock separation mechanism
25. entrance hatch towards the DM

An airlock exhibited in NPO Energiya's company museum in Kaliningrad. The lower ring with the four pressure air and oxygen tanks and the aeroboom structure can easily be distinguished. (The outer thermal protection seems to be omitted.)



Inside NPO Energiya's airlock looking up to the upper hatch and showing the base of the control panel.



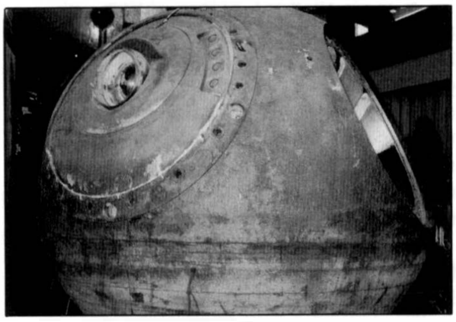
The airlock control panel is suspended by two pairs of bungee-cords. The grill prevents accidental operation of the switches.

aerodynamics, which could lead to position errors as well as to higher loads to the spherical descent module.

One airlock left over from the Voskhod-2 programme was sold at an auction for $80,000 (not including the Buyer's Premium) last December by Sotheby's in New York. The accompanying catalogue [6] reports that five airlocks have been built, two of these were damaged in tests, one was flown, one was sold, and the last is exhibited in Moscow's Memorial Museum of Cosmonautics. These five airlocks are probably flight type units, while more engineering models were previously built. One of these was exhibited in the company museum of NPO Energiya, where the accompanying photos of the interior were taken. Later (after May 1993) it was removed. The outer appearance of this unit is slightly different from the one in the Memorial Museum, which in turn compares very well with the photos in Sotheby's catalogue.

Voskhod 2 was the only EVA to test a soft airlock, all other spacewalks were performed through rigid spacecraft compartments serving as airlocks. in the Gemini and Apollo programmes the whole cabin was depressurised. in the two space station programmes Skylab and Salyut/Mir one compartment served as an airlock which was otherwise used as a transfer section. The Skylab section included system controls for the station. The Space Shuttle contains a specific airlock, which can only be used during missions for temporary storage purposes.

The original Voskhod 2 descent module is exhibited in NPO Energiya's company museum. The hatch between the DM and the airlock contains a window (left), which was used for navigation at deorbit. The flange to which the airlock was bolted encircles this hatch. The open parachute container is on the right. The bottom of the sphere shows the charred ablative heat protection.



References

1. P.S. Clark and R.F. Gibbons, 'The Evolution of the Vostok and Voskhod Programmes', ***JBIS*, 38**, January 1985, pp.7-10.
2. Dennis Newkirk, *Almanac of Soviet Manned Space Flight*, Gulf Publishing Company, Houston 1990.
3. I.P. Abramov, G.I. Severin and A. Ju. Stoklitskly, *Skaphandry i Systemy Dlya Raboty v Otkrytom Kosmose*, Mashinostroeniye, Moscow 1984, Fig. 8.3, p.221.
4. I.G. Borisenko, *In Outer Space*, NASA TT F-16252, Washington DC, May 1975, (Translation of: *V Otkrytkom Kosmose*, Mashinostroeniye, Moscow 1974).
5. M.V. Keldysh, (Ed), *Tvorcheskue Nasledie Akademika S.P. Korolyova*, Nauka, Moscow 1980.
6. *Russian Space History*, Catalogue and Auction Results to Sale 6516, Sotheby's New York, December 1993.

Soviet Orbital Space Station-1 Designed in 1965

The Soviet Orbital Space Station-1 (OS-1) design study and related mockup work was started as far back as 1965 by the Korolyov Design Bureau OKB-1.

A 75 metric ton Mono-Block core space station mockup was developed at OKB-1's own expense for launch on the very powerful N-2 booster yet to be developed. It was not intended to be an N-1 booster payload according to retired General Chief Designer Academician V.P. Mishin who volunteered the information upon viewing the smaller of the accompanying drawings.

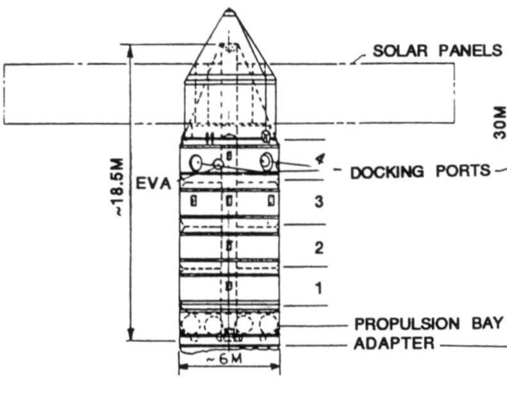
The present OKB-1 General Chief Designer, Yuri P. Semenov, characterised the station as an interplanetary station concept. This perhaps indicates that Academician S.P. Korolyov had both Earth orbit as well as Lunar uses under consideration when the concept was under consideration.

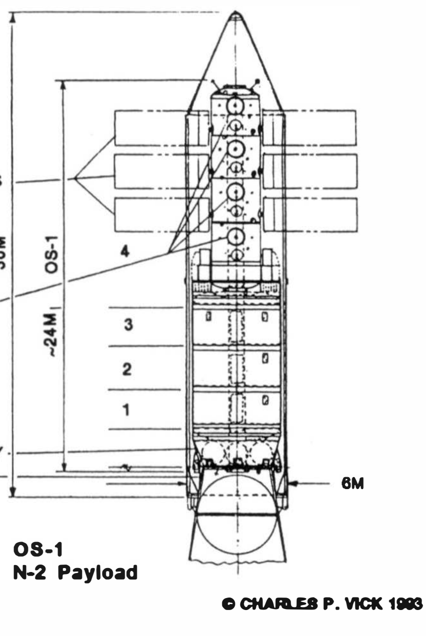
The four-floor baloney-slice station's bottom first floor had storage cabinets and facilities while the second floor was the crew compartment with its kitchen and toilets. The third floor of the Mono-Block station housed the laboratories and control section of the station while the fourth floor housed four docking ports and one of four EVA hatches. Both ends of the station housed single docking ports. The rear of the station carried its attitude control and propulsion systems while the top side of the station carried the solar arrays. So large was the mockup that it could be seen from the roads outside the Korolyov facility in its huge hangar outside Moscow.

The Ministry of General Machine Building, being the politicised organisation that it was, rejected this station concept because of design problems and other manned Lunar programme priorities. Within one year (1966) of this, OKB-1's competitor Acad. V.M. Chelomei OKB began design development work on the Proton-launched Salyut space station which was not approved by the ministry until 1969. Subsequent to this it has been learned that V.K. Karrask of the Chelomei Design Bureau had designed and developed a 6 metre diameter, 30 metre long shroud for the N1-L3M booster.

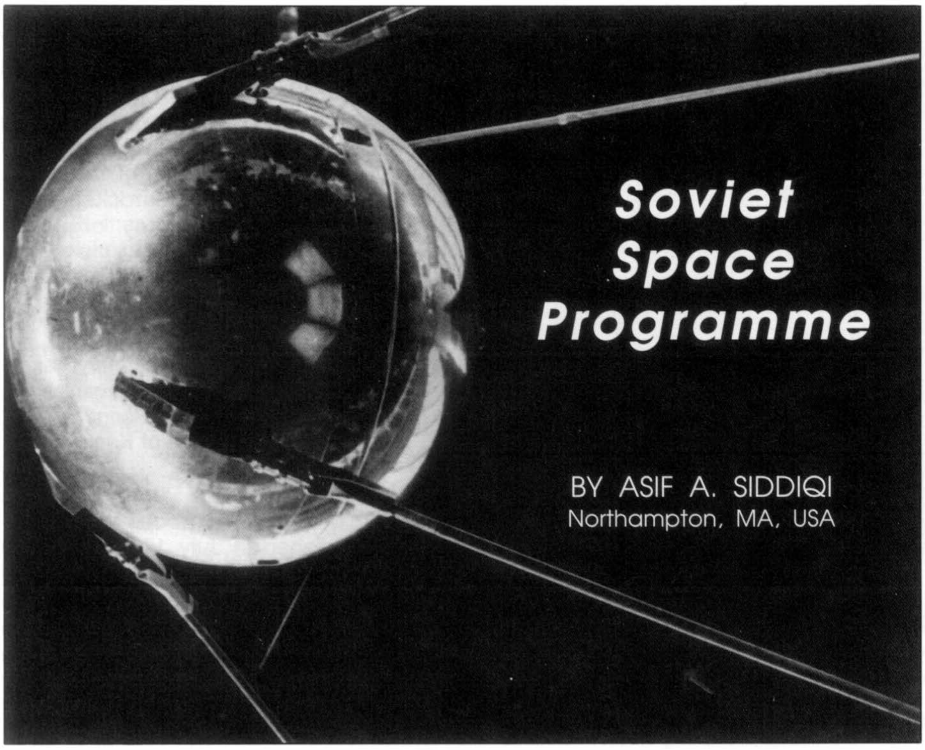
Perhaps this OS-1 station design evolved beyond the 1965 concept mockup. Presumably once the Mir-1 station assembly is completed it will represent the original OS-1 concept made real only through the cooperation of the two competing Design Bureaux.

Mono-Block Core Space Station 1965
75 metric tons





OS-1
N-2 Payload



The first Sputnik of October 1957, which impressed Khrushchev so much that he took a personal interest in the new space programme.

Part 1 - Organisational Structure 1940s-1950s

A major reassessment of the history of the Soviet space programme in the Western press has occurred in the past few years as a result of the large number of disclosures concerning various aspects of that programme. One area that has remained relatively unexamined in the light of these disclosures has been the organisational structure of the former Soviet space programme. Very little was known about the command-system of the programme until only two or three years ago; what little was known or inferred was often based on speculation more than on any solid evidence. It is now possible to make an early attempt to fill the gap for the first time, based upon recent official Soviet and Russian literature.

Before beginning this narrative, it is instructive to briefly describe the nature of the political structure of the former Soviet Union. On paper, the Communist Party of the Soviet Union (KPSS) and the government of the Soviet Union were two autonomous organs of the state. In the case of the defence and space programmes, all policy directives came directly from the top leaders of the KPSS.

Orders were then administered by the different bodies of the government, such as the Ministries, Chief Directorates, State Committees, State Commissions, etc. This chain-of-command was made easier due to the fact that many of the top leaders of the governmental structure were also high Party officials.

The KPSS structure normally originated from the Defence Council of the Presidium (later the Politburo), or from the Secretariat. Usually there was an individual in the Secretariat who was responsible for defence and space matters.

The next level of command was the Central Committee where the Defence Industries Department handled the space programme. From this level on, orders would be handed down to the top leaders in the *government* structure to accomplish the given projects.

Government: 1940s-1950s

The Soviet space programme had its industrial and administrative beginnings following the end of World War II when the government undertook a study of the possibility of very long-range rocketry as part of the defence of the USSR. On May 13 1946, less than a year after the end of World War II, the Soviet government signed the first decree for the development of ballistic missiles [1]. The missile industry was to be a special sector of 'machine building', a general euphemism for the defence-related industry. The May decree was followed by the organisation, in August 1946, of the Scientific Research Institute No. 88 (NII-88) for Jet Armaments within the USSR Ministry of Armaments in the city of Kaliningrad near Moscow [2].

Overall supervision of the work was entrusted to Minister of Armaments Dmitry F. Ustinov, while the principal organisational concerns were delegated to Ustinov's Deputy, Vasili M. Ryabikov. Most early work on ballistic missiles was centred at the NII-88 and it has been rumoured that the group may have reported directly to Soviet leader Josef Stalin in a somewhat informal manner and "above the heads of the ministers" [3].

The post as first Director of the NII-88 was filled by Leo R. Gonor, the former head of one of the largest artillery plants in the Soviet Union, while the Chief Engineer was named Yuri A. Pobedonostsev, a missile engineer who was soon transferred to the newly created Academy of the Defence Industry.

There were three principal structures created within the NII-88 to achieve the task of designing and building ballistic missiles:

1. An experimental plant;
2. A Special Design Bureau (SKB) consisting of several departments focusing on the design of missiles; and
3. A group of scientific subdivisions specialising in such areas as materials science, strength, aerodynamics, engines, fuels, control, testing and telemetry [2].

The SKB was headed by K. Tritko, the Chief Engineer of the plant where the NII-88 was located. Within the SKB itself, the division responsible for long-range missiles was delegated to Sergey P. Korolev who was appointed Chief Designer for the development of ballistic missiles by Ustinov himself on August 9 1946 [1]. Korolev at the time appointed a control systems specialist named Vasili P. Mishin to be his First Deputy.

This small department in the NII-88 eventually grew to become a design bureau in its own right and defined the principal thematic thrust of the NII-88 for years to come. A total of 52 engineers were employed by Korolev in August 1946 at Kaliningrad, including such later famous Designers as V.P. Mishin, B.E. Chertok, L.A. Voskre-

Sergei Korolev, chief designer of space rocket systems.

Valentin Glushko, designer of rocket engines.

senskiy, K.D. Bushuyev, D.I. Kozlov, V.M. Kovtunenko, V.P. Makeyev, M.F. Reshetnev, V.P. Radovskiy, M.K. Tikhonravov, B.V. Rausenbakh and P.I. Tsybin [2].

While the NII-88 was the primary organisation responsible for the design and development of long-range missiles, there were several other institutes who were assigned significant roles in the programme in 1946. These included the NII-885 headed by D. Maksimov and organised within the USSR Communications Equipment Industry. It was here that two other Chief Designers, Nikolai A. Pilyugin and Mikhail S. Ryazanskiy headed departments for automatic control systems and radio control systems respectively.

Additionally the NII-944 headed by Chief Designer Viktor I. Kuznetsov was given the responsibility of developing missile gyroscope instruments while Chief Designer Vladimir P. Barmin working within the Special Machine Building SKB of the USSR Ministry of Machine and Instrument Building was given the task of the design and construction of ground equipment in support of missile launches.

One of the most important responsibilities, the design and development of high-powered rocket engines was entrusted to the General Design Bureau No.456 (OKB-456) headed by Chief Designer Valentin P. Glushko.

A total of 25 Niis and KBs and 18 plants took part in the development of the first post-war Soviet ballistic missile, the R-1, essentially a modified German A-4 rocket. To streamline the widespread scattering of responsibilities, Chief Designer Korolev organised the Council of Chief Designers for the "operative resolution of all fundamental scientific and technical issues" [2]. The original Council comprised the six most important individuals in the programme for developing long-range ballistic missiles: Korolev (Head), Glushko, Pilyugin, Barmin, Ryazanskiy and Kuznetsov.

In the beginning, the Council was an informal and separate entity from the Niis, but was eventually to assume control of much of the early development of the Soviet space programme. One of its obvious advantages was that it circumvented the normal chain of command in the missile building industry and facilitated swifter and more efficient work.

Since the NII-88 was the primary organisation responsible for long-range missiles, a special top-secret branch, named the 7th Chief Directorate was created within the Ministry of Armaments to have direct oversight over long-range missile development. This Directorate was originally headed by S. Vetoshkin [4]. Essentially, the 7th Chief Directorate was to handle the design, procurement and production of all long-range ballistic missiles for the Ministry of Armaments.

Party: 1940s-1950s

While the above was the industrial (i.e. governmental) side of the new missile sector, measures were taken at the time to institutionalise a top-level Party body to determine policy issues that would be handed down to the government. Soon after the May 1946 decree, in April 1947, a special body named the Special Commission No.2 was created below the Presidium level (see Organisation Chart opposite).

This Committee, the first body in the Soviet government to direct the development of long-range weapons, was originally headed by KPSS Presidium member Georgy M. Malenkov, the number two official in the Soviet leadership after Stalin himself. Malenkov's Deputy for missile programmes was Minister of Armaments Ustinov, the individual directly responsible for the development of missile programmes in the government [4].

Its members were later expanded to include the top Party representatives of the various Ministries responsible in the development, construction and procurement of missiles in the USSR. These Ministries included: the Ministry of Armaments (under which was the NII-88); the Ministry of the Communications Equipment Industry; the Ministry of the Ship-building Industry; the Ministry of Machine and Equipment Building; and the Ministry of the Armed Forces. The latter was essentially the customer for the missile industry. Each Ministry had jurisdiction over a Scientific Research Institute that was involved in a particular aspect of the missile industry.

Clients: 1940s-1950s

The prime customer of the missile industry was the USSR Ministry of the Armed Forces (MVS), but it is clear from available descriptions that the MVS had little to do with actual missile development and building. The Main Artillery Directorate (GAU) under the jurisdiction of the MVS, however, exercised control of the rocketry programme through two key organisations:

1. The NII-4, a military institute organised to develop methods of testing, acceptance, storage and combat applications of missile weaponry; and
2. A group of 'rocket troops' organised at the State Central Test Range created in the area of the town of Kapustin Yar.

Named the Special Purpose Brigade (BON), these rocket troops were actually established in July 1946 within the Soviet Army. The first Commander of the BON was Maj.-Gen. A.F. Tveritskiy. Later in 1950, they were reorganised into the 23rd Special Purpose Engineer Brigade of the Artillery Force High Command Reserve (RVGK) headed by Col. Mikhail G. Grigoriev. Another Army officer named Lt.-Gen. Vasili I. Voznyuk was appointed the first Chief of the Test Range at Kapustin Yar. Thus the MVS had key influence on the missile sector by influencing the design of rockets through specific requirements which were developed at the NII-4, while at the same time directing the launch of all test rockets through the special unit of the MVS organised at Kapustin Yar [2,5].

Related Bodies: 1940s-1950s

With the advent of nuclear weapons, a special body was created within the USSR government to direct the construction of strategic nuclear weapons. This body, originally known as the 1st Chief Directorate was re-organised and named the Ministry of Medium Machine Building on June 26 1953 [6]. Its first Head, Vyecheslav A. Malyshev, was just six months later appointed a Deputy Chairman of the Council of Ministers.

It seems that this Directorate had more jurisdiction over the nuclear weapons development programme than the rocketry programme, although Soviet physicist Andrei Sakharov has stated that Malyshev's responsibilities were to direct the building of new military technology including missiles. Certainly in the 1950s, both programmes had many overlaps; in particular the specifications laid down by scientists employed by the 1st Chief Directorate had a profound influence on the specifications of the first Soviet Inter-Continental Ballistic Missile (MBR), the R-7.

1950s

Following Stalin's death, there seems to have been a period of transi-

tion during which the new leaders had less understanding of the workings of the strategic missile programmes. This may have stemmed in part from the fact that in many cases the NII-88 reported directly to Stalin, thus bypassing the official hierarchy of the industry.

Science Sector: 1950s

By 1955, the USSR Academy of Sciences (AN-SSSR) began to be involved in proposals for the first artificial satellite. In particular, its Vice-President, mathematician Mstislav V. Keldysh exerted a good deal of influence on the scientific specifications for the design of the first satellite. On August 30 1955, a special scientific Commission was formed under the jurisdiction of the AN-SSSR to develop a programme for the launch of the first artificial satellite [7]. Keldysh was named Chairman of this Commission, at the personal request of Chief Designer Korolev. It appears that this Commission or an extension of this Commission remained in existence for much of the early days of the space programme as an advisory panel to the government on space policy issues.

Government: 1950s

The management of the entire defense industry and thus the early space programmes of the USSR was performed by a very powerful body named the Military-industrial Commission (VPK), which essentially coordinated and controlled all defence-related research, design, development, testing and production activities [8].

Established in January 1938, all the appropriate Ministries and Directorates came under the direct supervision of the VPK which had a key input in policy decisions. At appears that by the later 1950s, its jurisdiction and powers had gradually increased.

Korolev's power within the administration of the rocketry programme had also increased throughout the 1950s. As far back as April 1950, he had replaced Tritko as head of the SKB within the NII-88 [9]. On September 1956, his group, i.e. this SKB, was detached from within the NII-88 and given the new designation Experimental Design Bureau No. 1 (OKB-1) [10]; by this time, Korolev's organisation was playing the undisputable lead role in the design of the first Soviet ICBM.

It appears that, on paper at least, Korolev reported through the head of the 7th Chief Directorate, to Minister of Defence Industries Ustinov, to the Chairman of the VPK, to the Special Commission No. 2, and finally to the new Soviet leader Nikita S. Khrushchev. This chain of leadership, however, became more of a formality than anything else following the launch of the first Sputnik in October 1957.

The first launch impressed Khrushchev so much that he took a personal interest in the new space programme and often consulted with Korolev himself.

The Council of Chief Designers appears to have exerted influence not only over programmes that had been approved by Khrushchev, but also began to have some input into programme starts and approval. In particular, the Council would often pass "resolutions" that were binding (albeit unofficially) for all the KBs and Niis involved. Final approval of programmes, more than often, rested with Khrushchev who often consulted with Ustinov, still the Minister of Defense Industries. It may be noted that the Ministry of Armaments was renamed the Ministry of Defence Industries in 1953, Ustinov still remaining its head.

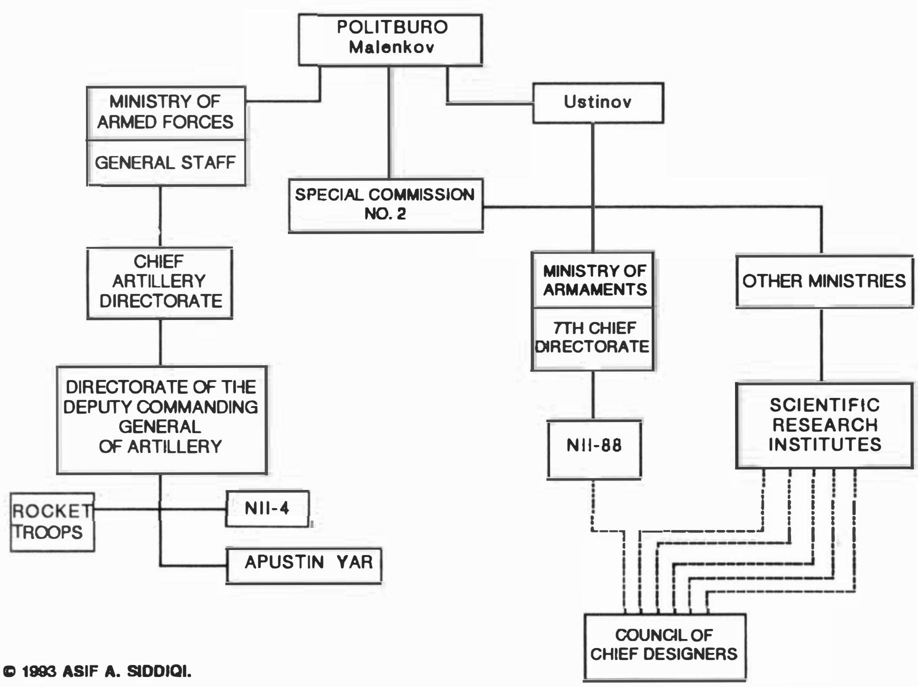
In the period 1957-1959, further changes were instituted in the governmental structure of the space and missile programmes. In late 1957, Khrushchev initiated certain reforms in the R&D structure of the military-scientific industry. As a result, institutions that were originally under ministerial jurisdiction acquired new labels, the majority of them transferred to State Committees under the Council of Ministers [11].

Thus R&D institutions in the Ministry of Defence Industry were transferred in late 1957 to the new State Committee for Defence Technology (GKOT). Konstantin N. Rudnev, a former Deputy Minister of the Defence Industry was appointed the Chairman of the GKOT in March 1958 [12]. Rudnev had served as Director of the NII-88 organisation in the early 1950's. The GKOT essentially took over the responsibilities of the Ministry of Defence Industries whose head had been Ustinov until 1957. The 7th Chief Directorate had in fact been transferred from the Ministry of the Defence Industries to be under the jurisdiction of the GKOT at this time [4]. Ustinov was meanwhile 'promoted' to be the new Chairman of the VPK in 1957 becoming Rudnev's immediate superior [8].

A special Commission was also formed in 1957 to monitor and approve the actual programme for launching the first satellites. Named the State Commission for Testing Boosters and Launches of the First Satellites, it was headed by Gen.-Col.-Engineer Vasili M. Ryabikov [13], who was also the Deputy Chairman of the Council of Ministers of the Russian Soviet Federated Socialist Republics (RSFSR).

Vasili Mishin, who was deputy to Sergei Korolev and later led the Korolev design bureau. He is seen here at the 41st International Astronautical Congress at Dresden, Germany in 1990.

Organisation of the Soviet Space Programme 1940s - 1950s.



Ryabikov had been appointed Ustinov's First Deputy in 1946 and had exerted a notable influence over the rocketry industry throughout the late 1940s and 1950s.

The powers of this precursor Commission appear to have been restricted to the monitoring and approval over actual launches rather than supervision over any policy issues. Following the first satellite launches in the 1957-1958 period, this temporary body was re-organised and renamed simply the State Commission in 1958; its powers were extended to the day-to-day direction of the space programme.

Organisations such as the State Commission were common at that time in Soviet industry and their duties were essentially to make sure that certain guidelines were followed in the facilitation of important programmes. Heads of State Commissions were always prominent individuals in the defence sector.

Rudnev, already the Chairman of the powerful GKOT, was also appointed the first Chairman of the State Commission for the Space Programme in early 1958, thus assuming two of the most powerful administrative positions in the space programme. Thus, Rudnev not only exercised control over the day-to-day administration aspects, but also exercised key control over the industrial aspect of the space programme as Chairman of the GKOT. Rudnev reported directly to VPK Chairman Ustinov.

The new State Commission for the Space Programme comprised of 16 core members by 1960 as shown in the table on the right.

Through the ensuing years, the membership was expanded to include other Chief Designers and government officials, as the requirements for particular missions changed.

State Commission for the Space Programme 1960.

Chairman:	
Konstantin N. Rudnev:	Chairman, State Committee for Defence Technology
Members:	
Boris Y. Butoma:	Chairman, State Committee for Shipbuilding
Pyotr V. Dementyev:	Chairman, State Committee for Aviation Technology
Valery D. Kalmykov:	Chairman, State Committee for Radio and Electronics
Mstislav V. Keldysh:	Vice-President, USSR Academy of Sciences
Rodion Y. Malinovsky:	Minister of Defence
Mitrofan I. Nedelin:	Commander-in-Chief, Strategic Rocket Forces
Sergey I. Rudenko:	Deputy Commander-in-Chief, Soviet Air Force
Vasili M. Ryabikov:	Deputy Chairman, RSFSR Council of Ministers
Dmitry F. Ustinov:	Deputy Chairman, Council of Ministers
Designers:	
Vladimir P. Barmin:	Chief Designer, SKB for Machine Building
Valentin P. Glushko:	Chief Designer, OKB-456
Sergey P. Korolev:	Chief Designer, OKB-1
Viktor I. Kuznetsov:	Chief Designer, NII-944
Nikolai A. Pilyugin:	Chief Designer, NII-885
Mikhail S. Ryazanskiy:	Chief Designer, NII-845 [14].

Party: 1950s

As the highest organ in the governmental sector of defence and space, the VPK maintained direct contact with the Party structure (i.e. with the real power). It seems that the person below Khrushchev in determining space policy was Leonid I. Brezhnev. He had been appointed Secretary of the Central Committee in 1956 and remained in that position until 1960 overseeing matters of "heavy industry, construction, modernisation of military weaponry and space flight" for the Party [15]. Khrushchev and Brezhnev thus determined the actual course of the space programme during that period.

References

1. German Nazarov, "You Cannot Paper Space With Rubles," *Molodaya Gvardiya* 4:192-207 (1990).
2. Yu. Mozzhorin and A. Yeremenko, "From the History of Space Science: From the First Ballistics to....," *Aviatsiya I Kosmonavtika* 7:40-41 (1991).
3. Stephane Chenard, "Twilight of the machine builders," *Space Markets* 5:11-19 (1991).
4. Yu. Mozzhorin and A. Yeremenko, "From the History of Space Science: From the First Ballistics to....," *Aviatsiya I Kosmonavtika* 8:34-35 (1991).
5. V. Litovkin, "Without the 'Secret' Stamp (For the First Time Colonel General V. Ivanov Describes the USSR Ministry of Defence Space Units)," *Izvestiya*, December 12 1990, p.6.
6. Andrei Sakharov, *Memoirs*, Alfred A. Knopf, New York, 1990, p.169.
7. Yaroslav Golovanov, "The Beginning of the Space Era," *Pravda*, October 4 1987, p.3.
8. Directorate of Intelligence, *The Soviet Weapons Industry: An Overview*, Central Intelligence Agency DI 86-10016, September 1986.
9. Lt.-Gen. (Ret.) G. Tyulin, "The 'Seven': Years, Accomplishments, People," *Krasnaya Zvezda*, April 1 1989, p.3-4.
10. Maxim Tarasenko, *Military Aspects of Soviet Cosmonautics*, Agentsvo Rossiskoy, Moscow, 1992, p.34.
11. Alexander G. Korol, *Soviet Research and Development*, The M.I.T. Press, Cambridge, 1965, p.17.
12. *Ibid.*, p.332.
13. B. Konovalov, "Lessons of the First Satellite," *Izvestiya*, September 29 1987, p.3.
14. M. Rebrov, "The Difficult Path to April 1961, or Why We're Not Finding Out the Entire Truth About the Flight of Yu. Gagarin Until Today," *Krasnaya Zvezda*, March 28 1992, p.3.
15. Peter Potichnyj, ed., *Current Soviet Leaders*, Volume 3, Number 1, 1976, pp.3-4.

Selected Sources for Organisation Chart:

1. Maxim Tarasenko, *Military Aspects of Soviet Cosmonautics*, Agentsvo Rossiskoy, Moscow, 1992, p.15.
2. Y. Mozzhorin and A. Yeremenko, "From the History of Space Science: From the First Ballistics to . . .", *Aviatsiya I Kosmnavtika*, 8 (1991), pp.34-35.

Soviet Space Artifacts Sold

The Lunokhod 2 rover that is still on the Moon sold for nearly $70,000 at a Sotheby's auction last December. The auction house felt obliged to note that transfer of title to the Lunokhod 2 lunar rover - and the descent module that got it there - did not imply that the auction house would actually bring it back to Earth.

In another 'inaccessible' purchase, more than $13,000 was paid for a guitar that has been circling the Earth since 1987 aboard the Russian space station Mir. More than 200 artifacts from three decades of Russian space exploration fetched a total of $6.82 million in the sale.

Two Soviet space capsules sold for $1.6 million and $552,500 and the Tokyo Broadcasting Corporation paid $230,000 for the spacesuit used by Japanese journalist Toyohiro Akiyama, who became the first reporter in space when he travelled aboard Soyuz 10 and Soyuz 11 in 1990.

Gagarin's original report of his flight, meanwhile, fetched the fourth-highest price of the day when it sold for $354.000, 10 times the presale estimate. The orange spacesuit that Gagarin trained in before his flight sold for $112,500, while his Soviet Air Force dress uniform went for $34,000.

Among the more esoteric items was a slide-rule that was used by Sergei Korolev, chief designer of the Soviet space programme. Nicknamed "the magician's wand", the slide-rule sold for $24,000. See Reference 6 on p.282. Further auctions of Soviet space items are being arranged.

Space Policy Takes in the Outer Solar System

Pluto Mission Recommendation

Last Opportunity for Almost 250 Years

The Society with the support of many leading UK scientists has recently written to the Administrator of NASA setting out the case for a Pluto/Charon mission and the urgency that attends its implementation.

The scientific and technical merits of a spacecraft mission to Pluto have been the subject of four articles in ***Spaceflight*** during this year.

The discovery of several small outer Solar System bodies and the refurbishment of the Hubble Space Telescope have placed the outer Solar System firmly on the research agenda and highlighted the need for such a mission.

The following letter from the Society was submitted with a list of the major scientific reasons for the mission endorsed by over thirty UK leading scientists. The major scientific reasons for the mission were put forward in ***Spaceflight*** on p.244 of the July 1994 issue.

From the British Interplanetary Society to Dan Goldin, NASA Administrator:

Dear Mr Goldin,

I am writing to you on behalf of this Society and a considerable number of leading figures in British Science who believe that the study by spacecraft of the planet Pluto, while its atmosphere remains in its active 'high-temperature' state and before it re-condenses upon the planet's surface, is of prime importance to the fundamental scientific understanding of the formation of the Solar System and its subsequent evolution.

On the best present estimate, the process of atmospheric re-condensation will be completed somewhere between 2016 and 2025 AD, after which there will be no further possibility of studying the active state of the planet until it approaches perihelion several hundred years hence. The justification for giving a Pluto mission high priority is its overriding scientific importance and the fact that, if the current opportunity for a space mission is lost, there will be no way of gathering such important scientific data for many years.

Recent advances in our knowledge of the satellites of Neptune, particularly of Triton, and of Pluto itself through the study of the Pluto/Charon eclipse cycles, and the discovery in the past 18 months of six putative Kuiper belt objects, four orbiting at heliocentric distances between the mean orbital distances of Neptune and Pluto and two beyond, have all emphasised the scientific importance of outer Solar System studies. The accumulating evidence is highly suggestive that Pluto may well be the largest surviving primordial planetesimal, so we believe that the data that could be obtained while the planet's atmosphere is active will provide a wholly new window on the earliest stages of the evolution of the Solar System, particularly in relation to the composition of the preplanetary solar nebula.

The mass of the presently active Plutonian atmosphere may have already commenced its decline as it enters its seasonal re-condensation cycle and the fact that atmospheric re-condensation is calculated to be completed by, or within, the period 2015 to 2025 AD, stresses the importance of adopting a fast flight trajectory mission. This would allow Pluto to be studied at least a decade ahead of the closest estimated date for the completion of re-condensation of the atmosphere. Of the current options that NASA has under study, the JPL Pluto Fast Flyby Mission proposal appears to offer the greatest scientific potential as it allows Pluto to be studied a decade sooner than a 2001 launch window gravity-assist swing-by mission.

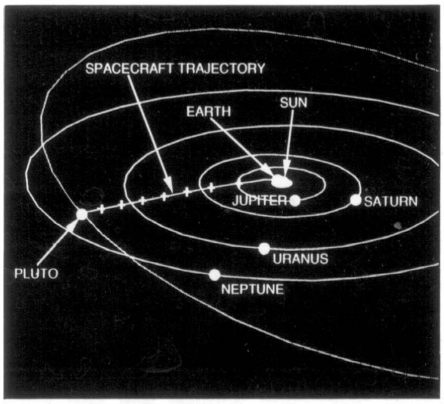
We have set out some of the major scientific reasons which, in our view justify undertaking a Fast Flyby Mission to Pluto as a matter of urgency and also append expressions of support from 33 UK scientists and academics who have responded so far and who believe that, even in these times of great financial stringency, the study of Pluto is of such unique importance that a Fast Flyby Mission should be considered as of the highest possible priority.

We recognise the difficulties in evaluating and deciding between many worthy projects but hope that the support shown for the Pluto Project, as evidenced by these signatures, will be of assistance in this task.

Yours sincerely
L.J. Carter
Special Projects Officer

NASA has since held a four-day session at JPL with a party of Russian officials and representatives of US establishments and the US science community on joint missions to Mars, Pluto and the Sun.

One of the options being considered for a Pluto mission is a 110 kg fast flyby spacecraft (see **Spaceflight**, March 1994, pp.101-104) to be launched on a Proton booster in the year 2000. It would carry a 10-15 kg Russian descent vehicle which would either fly through the atmosphere or take atmospheric measurements during a terminal descent. If two small Russian vehicles were used the second could investigate Pluto's satellite, Charon, if the first vehicle found the moon to have an atmosphere. The flight to Pluto would take six to seven years.



Pluto Fast Flyby. JPL

Spaceline

News Service Supports Society Funds

Clive Simpson

Space journalist Clive Simpson is now compiling and presenting ***Spaceline***, the Society's telephone news-line for international space news.

A former assistant editor of ***Spaceflight***, Clive has also worked recently for the Anglo-French satellite manufacturer Matra Marconi Space. He is currently involved in freelance writing and editing, mainly in the space business.

Spaceline was established by the Society over three years ago. It is successful with both members and the public phoning in regularly to keep abreast of the latest space news.

"Bulletins will be up-dated on a regular basis and more frequently when important missions are taking place", said Clive, who has been a Society member for 15 years. General updates will normally be made on Tuesday and Friday early evenings.

Shirley Jones, Executive Secretary, added: "***Spaceline*** is the ideal way of keeping abreast of developments as they happen - between issues of ***Spaceflight*** of course! We are pleased Clive has taken on this position and we are sure it will benefit from his experience and expertise".

Profits from ***Spaceline*** support Society funds and the number to call is 0891 88 1975. Calls cost 39p per minute off-peak and 49p per minute at other times.

Picometers, Photons and Gravity Waves

The Uses of Interferometers for Space-Based Astronomy

Dr W.I. McLaughlin,
Jet Propulsion Laboratory

Evening Lecture to the Society, 16 March 1994

Behind the esoteric title of this lecture there was much basic physics and technological development which when practically applied will add considerably to the potential of space-based astronomy.

The physical principles which allow light to be manipulated to produce patterns of interference - "fringes" - were reviewed. The fringes, in turn, allow deductions to be made concerning the precise geometry of the scene being observed, e.g., if the scene is composed of stars on the celestial sphere the set of interferometric observations would constitute "astrometry".

In order to achieve astrometric measurements at the microarcsecond level of precision, it is necessary to understand the configuration of the measurement apparatus at the picometer (10^{-15} meter) level, a challenge which has been met in the laboratory and can be met in space. Modern laser technology (for metrology of the system) and techniques to "quiet" space structures, which are subject to thermal and mechanical stresses, are essential for the success of the enterprise and are currently being vigorously pursued by NASA.

The Astrometric Interferometry Mission (AIM) of NASA was described. It is planned as a major thrust, to be launched early in the next century, to accomplish microarcsecond interferometry. In addition, NASA is planning, under its ASEPS (Astronomical Search for Extra-Solar Planetary Systems) programme, to search for planets about other stars, and astrometric measurements of the "wobble" of the orbited star through interferometry is a candidate technique. (The other candidate is direct imaging of the orbiting planet or planets).

The scientific potential of interferometry is enormous for astrometry, imaging, and even the detection of gravitational waves. With its great economy of mass and cost - using partially filled apertures to do the job - and its technological elegance, interferometry is a discipline whose time has come.

Accelerating Development

Dr Yash Pal Receives Award

Arthur C. Clarke, a former President of the Society, is keenly active in many roles and none more so than as Patron of Sri Lanka's A.C. Clarke Centre for Modern Technologies (ACCMT).

In recent times, the Centre has pioneered the introduction into Sri Lanka of modern technologies such as Satellite Communications, Computers, Space Science, Robotics and Electronics. It is now moving into new areas such as computerized electronic design, electronic mail and data networks.

Selected for the Arthur C. Clarke Lecture Award of 1994 by the Board of Governors of ACCMT was Dr Yash Pal of the Consortium of Educational Communications of New Delhi, India. The award is conferred annually for outstanding contributions to modern technologies, especially in the field of satellite communications. Dr Yash Pal was responsible for bringing the benefits of satellite technology to the vast rural areas of India. The

ASSOCIATED NEWSPAPERS OF CEYLON LIMITED

Indian Space Research Organisation and the Space Applications Centre, formerly headed by Dr Yash Pal, have contributed in large measure to India achieving its formidable position in the field of space applications.

The award presentation to Dr Yash Pal was made by President D.B. Wijetunga of Sri Lanka on 2 June. In the photo applauding are the Prime Minister Ranil Wickremesinghe and Dr Arthur C. Clarke. After the presentation, Dr Yash Pal delivered his lecture on 'From Cosmos to Villages: a Personal Story'.

'Find the Space Travellers' Competition Winners

Winners to whom prizes will shortly be dispatched are:

D.H. Boardman	UK
J. de Roo	The Netherlands
B. Vis	The Netherlands
R.J. Townsend	UK
M. Heirman	Belgium

The correct answers are: Akiyama, Frimout, Gagarin, Garneau, Malerba, Merbold, Mohmand, Sharman and Shepard. They were the first astronaut/cosmonaut of their country into space.

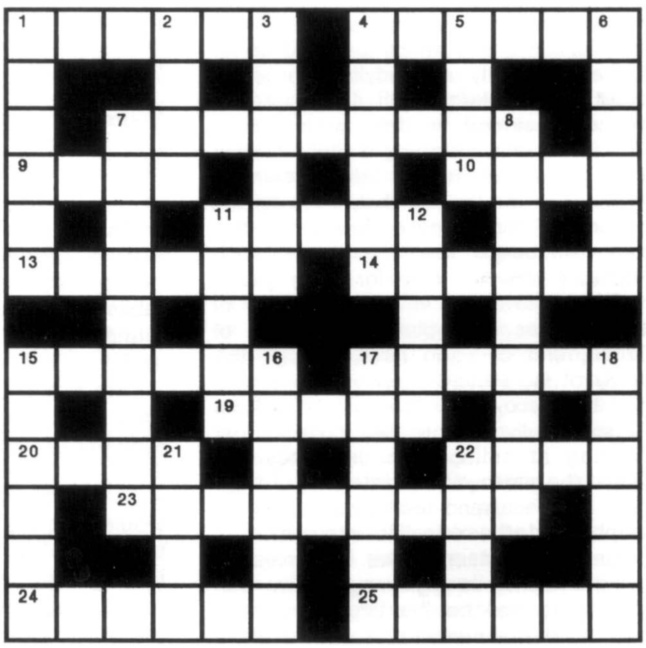
Spaceflight Crossword

No. 12

ACROSS
1. Bullish space launcher
4. Put (into orbit)
7. Surveillance vehicle (6,3)
9. Change course
10. Flower that flew up from the ground ?
11. Third degree, mathematically speaking
13. Departs
14. Deferments
15. Rides a bike
17. Character constant in computer language
19. Purgative
20. Travel by shuttle for astronaut Sally ?
22. Intelligence given in abbreviated form
23. Discoverers, people and spacecraft alike
24. Lifted up
25. Hollowed by a blow

DOWN
1. Space ——
2. Rocket engine noise
3. Dogstar
4. Having a pattern set into its surface
5. Heavenly body
6. Clocks set to go off
7. Punishing regulations (5,4)
8. Turns about an axis
11. Largest asteroid
12. Coins
15. Metal used for plating
16. Set out on a voyage
17. Kept in reserve
18. Prevent from flying
21. Way out
22. Most used metal

Solution will appear in the September issue.



Solution to Crossword No.11.

ACROSS: 1. Outer; 4. Space; 10. Bestial; 11. Nancy; 12. Ratio; 13. Oderacs; 15. Dare; 17. Aches; 19. Every; 22. Tape; 25. Concept; 27. Civil; 29 Epoch; 30 Moonlet; 31. Least; 32. Askew. **DOWN:** 2. Upset; 3. Episode; 5. Pence; 6. Centaur; 7. Abort; 8. Floor; 9. Gypsy; 14. Deep; 16. ASTP; 18. Console; 20. Vectors; 21. Scree; 23. Atoms; 24. Pluto; 26. Ethos; 28. Value.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated. ***Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.*** It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight/JBIS*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

7 September 1994 — 7 - 8.30 pm

What Must We Change For Low Cost Space:
Management, Politics or Technology

C.J. Elliott

Early space programmes were cheap and effective, whereas a mission like Envisat takes 15 years and costs 1500MAU. This lecture examines the drivers that force up the costs of space missions and seeks ways that might lead to falling costs and shorter development times.

13 September 1994 — Provisional

BIOS 3 and Biospherics

Nicolai Pechurkin

Work on long duration astronaut life support experiments at the Institute of Biophysics, Krasnoyarsk, which is a world leader in the field of life support systems, is described. *(To be confirmed.)*

15 September 1994 — 5.30 pm for 6.00

Advanced Launchers
to be held in The Royal Aeronautical Society Lecture Room
4 Hamilton Place, London W1V 0BQ

R.C. Parkinson

Studies in progress in Europe for selecting a future launch system are summarised and criteria for making an eventual choice are suggested.

R. Varvill

The economic objectives and design of the Skylon spaceplane and the Sabre engines which propel it are described.

No tickets required and visitors welcome. Refreshments will be availabe from 5.30pm. This lecture has the cosponsorship of the Society.

6 October 1994 — 7 - 8.30 pm

The First Manned Lunar Landing Spacecraft:
Its Design, Manufacture, Ground Test and Mission

R. Fleisig

The Apollo 11 space vehicle is described with emphasis on Lunar Module 5 (LM-5). Finally the mission itself with LM trajectories is reviewed.

Hubble Repair Mission Astronaut
Claude Nicollier

at

The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1

at 4 pm on

Saturday, 24 September 1994

ESA Astronaut and BIS Fellow Claude Nicollier will talk about his work and the Hubble Repair Mission of December 1993.

Members are cordially invited to attend. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

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2 November 1994 — 7 - 8.30 pm

Chinese Space Programme

P. Clark

A review of the programme's history, a look at its current status and an attempt to predict in which directions we can reasonably expect the programme to continue.

SYMPOSIUM & CONFERENCES

29 August - 1 September 1994

Practical Robotic Interstellar Flight: Are We Ready?

New York University
(9am - 5pm on four days)
The UN (evening 30 August)

Technical Sessions: Interstellar Flight Concepts; Spacecraft Engineering Considerations; Extrasolar Planetary Systems; Intermediate Prestellar Destinations.

Cosponsored by the Society in conjunction with 11 other organisations.

15 September 1994 — 10-4.30 pm

Space Transportation and Infrastructure

For details see p. 267.

9-14 October 1994

45th IAF Congress
"Space and Cooperation for Tomorrow's World"

The 45th Congress of the International Astronautical Federation will be held in Jerusalem, Israel, October 9-14, 1994. There are 98 technical sessions planned.

A large exhibition on space technology will be held with exhibitors from Israel and other countries.

Details of the Programme are available from the Society. Please enclose a 19p stamp.

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

Society's Postal Ballot

Proposed Extension of the Procedure for the Taking of Polls at General Meetings of the Society and Amendment of Wording of the Form of Proxy

Report of the Scrutineers

Our Report as Scrutineers on the Ballot Papers counted up to and including 1st June 1994 is as follows:

Number of Papers received	678
Number of Spoilt Papers including blanks	7

The totals of Votes Cast were as follows:

Those Supporting the Amendments	603
Those Against the Amendments	68

The Amendments are accordingly declared Carried.

A.P. Black, FBIS
E.M. Waine, FBIS
1st June 1994

Consequent on the above result of the Society's Postal Ballot, Articles 29 and 39 of the Society's Constitution are as follows:

29. Subject to the provisions of Article 30, if a poll be demanded in the manner aforesaid, it shall be taken either forthwith or at such time and place or by postal ballot and in such manner as the Chairman of the meeting shall direct, and the results of the poll shall be deemed to be the resolution of the meeting at which the poll is demanded.

39. Any instrument appointing a proxy shall be in the following form or as near thereto as circumstances allow or in any other form which is usual or which the Council may approve: -

"I,
"of
"a Corporate member of The British Interplanetary Society Limited
("hereinafter called 'the Society')
"hereby appoint the Chairman of the Meeting
("who is also a Corporate member of the Society)
"or failing him
("who is also a Corporate member of the Society) of
"as my proxy to vote for me and on my behalf at the Annual or Extraordinary or
Adjourned, as the case may be, General Meeting of the Society to be
held at on the day of 199 at
and at every adjournment thereof.
"I direct my proxy to vote as follows:-
"Please indicate with an "X" in the appropriate space how you wish your
vote(s) to be cast.

Resolution 1	For ...	Against ...
Resolution 2	For ...	Against ...

"Unless otherwise directed, the proxy will vote or abstain from voting as he thinks fit."

Signed:
Date:

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Spaceflight

The International Magazine of Space and Astronautics

ESA Astronauts for Mir

UK's European Space Role

Clementine Mission

- Jupiter Comet Impact
- Mars Armada: 1996-2003

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The BIS Video Collection

The BIS is proud to offer a stunning record of man's exploration of space brought to your home on video.
All videos are extracted from original footage.

NEW TITLES

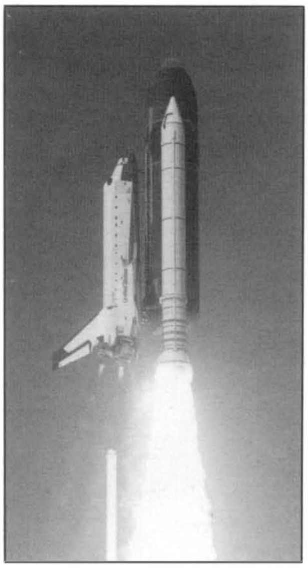
STS-57 : Mission Highlights

Raw footage with titles only and minimal soundtrack featuring the Endeavour launch on a 10-day mission on 21 June 1993 with a crew of Grabe, Duffy, Low, Sherlock, Wisoff and Voss. The flight featured experiments with Spacehab, a pressurised module attached to the orbiter mlddeck by a short pressurised passage, carrylng over 20 different experiments in locker-type drawers.

Its other payload, which was recovered from space after almost a year investigating materials microgravity research, was ESA's Eureca satellite, deployed by STS-46. The remote arm was successfully used to grab the satellite and draw it into Endeavour's payload bay for return to Earth.

59 mins

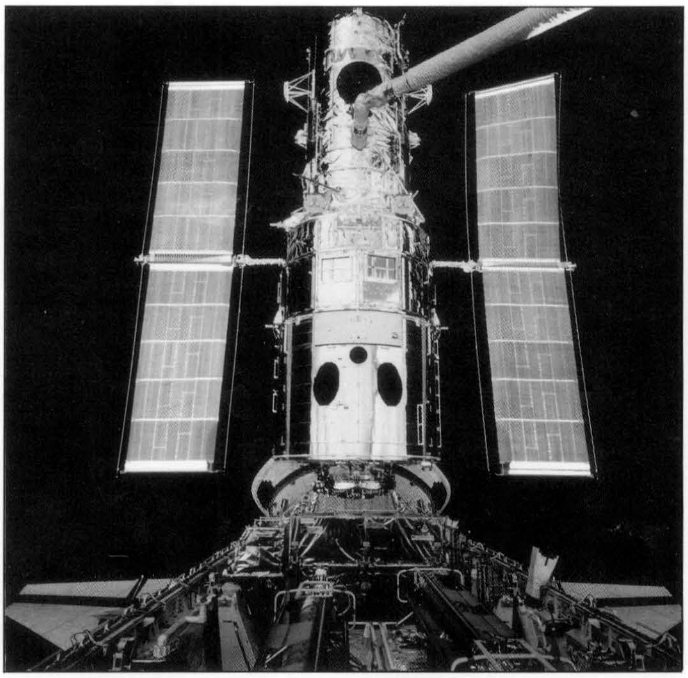
STS-58: Mission Highlights



Raw footage with minimal sound track of the "third time lucky" launch of Columbia on 18 October 1993 into its record-breaking 14-day flight during which the crew of seven (Blaha, Searfoss, Seddon, McArthur, Wolf, Lucid and Fettman) conducted a multitude of studies with the Spacelab Life Sciences 2 Module.

The main emphasis was on metabolic and cardiovascular studies to see how microgravity affects the human body. Various levels of exercise were carried out, using a stationary bicycle ergometer. Scenes were taken for an eventual educational film on the life sciences.

59 mins



Hubble Repair Mission

STS-61: Mission Highlights

Raw footage with minimal soundtrack of STS-61 launched on 2 December 1993. This 11-day flight was a major mission by Endeavour and its crew of seven (Covey, Bowersox, Musgrave, Hoffman, Akers, Thornton and Nicollier) to repair the faulty Hubble Space Telescope. Features spectacular EVAs. Major elements included changing the solar arrays and replacement of the Wide Field Planetary Camera with one which corrected the Hubble Mirror by reconfiguring the relay mirrors.

Work on the Telescope was likened by the crew as akin to "eye and brain surgery in space". The first response by astronomers to the successful mission was "Hubble Trouble is Over!".

2 hours

❐ STS-57 Mission Highlights	£15	(US$27)	❐ STS-37: Post-Flight Press Conference	£15	(US$27)
❐ STS-58: Mission Highlights	£15	(US$27)	❐ STS-46: Mission Highlights	£15	(US$27)
❐ STS-61 Mission Highlights	£18.50	(US$34)	❐ STS-49 Mission Highlights	£18.50	(US$34)
❐ Space Shuttle: A Remarkable Flying Machine	£11	(US$20)	❐ STS-49 Post-Flight Press Conference	£11	(US$20)
❐ STS 41-C: The Repair of Solar Max	£15	(US$27)	❐ STS-54: Mission Highlights	£15	(US$27)
❐ Space Shuttle Challenger: Accident Investigation	£11	(US$20)	❐ Time of Apollo	£11	(US$20)
❐ STS-26: The Return to Flight	£15	(US$27)	❐ The World Was There	£11	(US$20)
❐ STS-31: The Hubble Deployment	£15	(US$27)	❐ Skylab: The First 40 Days	£11	(US$20)
❐ STS-32: The Recovery of LDEF	£15	(US$27)	❐ Skylab: The second Manned Mission	£15	(US$27)
❐ STS-37 Video Highlights	£15	(US$27)	❐ Mission of Apollo-Soyuz	£11	(US$20)

For a full list of BIS video cassettes please send a SAE to the address below.
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I enclose a cheque/PO/International Money Order payable to the British Interplanetary Society totalling £ ....

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Spaceflight

The International Magazine of Space and Astronautics

Published By The British Interplanetary Society
Vol. 36 No. 9 September 1994

Front Cover: **Parabolic flight training for ESA's astronaut candidates on an Ilyuschin IL-76 MDK. In the white suits (from the right as seen in the photo) are Christer Fuglesang from Sweden, Pedro Duque from Spain and Marianne Chell from Belgium, assisted by their Russian instructors.** ESA

Future as a Space Nation Under Threat

Cost-cutting proposals on UK government spending could spell the end to British involvement with European space programmes and the death-knell for a thriving industry.

A Cabinet confrontation over industrial and spending policies entered the public domain with the publication of a private letter from former Treasury Chief Secretary Michael Portillo to his Cabinet colleague Michael Heseltine, Head of the Department of Trade and Industry, calling for more cuts in public spending. It singled out space as an activity that could not only be cut, but abolished altogether.

"Space is a good example where a European programme makes a UK one unnecessary and an area where we can be bold. Given, moreover, that it appears to lack a market failure of competitiveness rationale, I do not see why you do not move straight to abolition. You should also reconsider ESA membership as soon as current commitments permit," wrote Mr Portillo.

Government spending on space research in the UK is aimed at encouraging industry to exploit opportunities in space - it includes Earth observation, the British National Space Centre (BNSC), and a subscription towards the activities of the European Space Agency (ESA). Pulling Britain out of European activities alone could save around £100 million a year.

"The UK makes a valuable contribution to Earth observation and space science in Europe and around the world. If the plug is pulled on funding the financial return from ESA - which is over one to one terms of contracts - would also disappear," said one BNSC official.

The new space minister, Ian Taylor MP, had hardly been welcomed aboard the Government front benches when the cost cutting salvo was launched in his direction.

"Space can be no exception to the need for partnership between industry and government," he told MPs before the summer recess and before the contents of the Portillo letter had been revealed. "Our membership of ESA remains an important part of our space policy. Cooperation between the Government and industry is very important".

Quitting ESA would have serious implications for the 6,000 employees of the UK space industry which between them generate an annual turnover of £500 million. According the United Kingdom Industrial Space Committee (UKISC), which promotes the interests of British space companies, a past failing of ESA has been its inability to turn good ideas into commercial products.

"ESA is not market orientated but things are beginning to change. The UK has the moral high ground and is in a strong political position to take advantage of the initiatives that are developing. Not only would leaving be disastrous, it would be untimely", said UKISC spokesman Alan Hicks. "Without access to ESA programmes UK industry would be shut out of the commercial developments. We have a voice in helping to influence future strategy and we don't want to lose it."

Only ten days previously, in an adjournment debate, Cheryl Gillan MP, secured the first opportunity in the House of Commons since 1988 of discussing UK space policy and industry.

"ESA has served Europe well but it now appears to have lost its way in the prevailing political circumstances. We need strong political leadership because past decisions have left us outside the mainstream of ESA thinking. It is ironic that being proved right about Hermes has not endeared us to those who have tried and failed," she said.

Calling for an urgent review of space policy, Mrs Gillan told MPs that a ceiling on space expenditure meant the UK was virtually ostracised from new ESA programmes. CLIVE SIMPSON

New Space Minister

Ian Taylor MBE, who was appointed Parliamentary Under-Secretary of State for Trade and Technology on 21 July 1994, has responsibility for the British National Space Centre.

His remit also includes telecommunications, the Radiocommunications Agency, industrial research establishments, technology and innovation policy, management technology and technology services and the Patent Office.

Mr Taylor was born in 1945 and educated at Whitley Abbey School, Coventry, Keele University and the London School of Economics. He has been the Member of Parliament for Esher since June 1987. Previously he has worked in the corporate financial services sector, in merchant banking and stockbroking, principally assisting developing companies. He is an Associate of the Institute of Investment Management and Research, a Fellow of the Institute of Directors and of the Royal Society for the Arts.

On the day of his appointment, the new minister found himself in the House of Commons replying in an adjournment debate on UK space policy and industry, a report of which begins on the opposite page. In opening his reply, he said, "Certainly, I did not expect to have the honour of replying to my hon. Friend (Mrs Gillan) until a short time before she got to her feet. However, that is one of the excitements of assuming a ministerial office and learning about the portfolios that one is honoured to have at one's disposal". ■

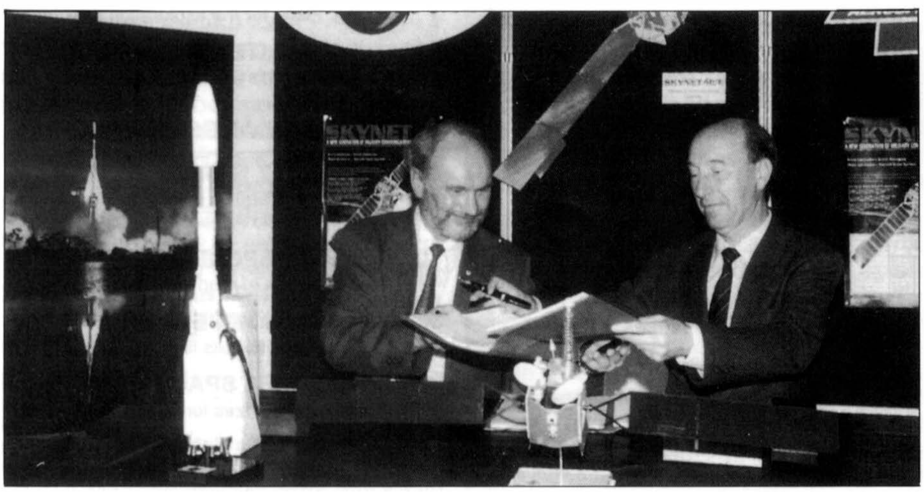
London Signing

On 22 June, Brian Oke, Chairman of British Aerospace Space Systems Ltd, and Charles Bigot, Chairman of Arianespace, signed the contract for the launch of the Skynet 4E satellite, in the presence of officials from the Ministry of Defence, numerous UK government guests and representatives of the British space industry. Skynet 4E will be launched in the third quarter of 1998 to replace the first-generation spacecraft, which by then will have been operational for more than their seven-year design life.

Later on the 22 June, Arianespace's Chairman, at the invitation of Sir Michael Marshall MP, president of the Parliamentary Space Committee, visited the House of Commons and fielded questions from a large audience.

(On 21 July, British Aerospace Space Systems Ltd was sold to Matra Marconi Space - see p.293)

Mr Brian Oke and Mr Charles Bigot signing the Skynet 4E launch contract in London. ARIANESPACE



Commons' Debate

UK's European Space Role

Cheryl Gillan MP.

On 21 July, time was given by the House of Commons to the subject of the UK's position in the space industry. In her speech, Mrs Cheryl Gillan (MP for Chesham and Amersham) pointed out the changing European space scene including, amongst other things, the increasing involvement of the European Commission and emphasised the urgent need for a UK review of space policy. In reply, the new space minister, Mr Ian Taylor MP, stated the Government's views and intentions. The following is an edited version of the proceedings.

Mrs Gillan: I am delighted to have secured this opportunity to raise the subject of the UK's position in the space industry, an issue that has not been properly debated in the House since 1988. It is also apposite as this week there have been widespread celebrations to mark the 25th anniversary of the Moon landing, a remarkable feat for mankind. However, several matters need to be examined urgently in relation to UK space policy, not least because in September 1995 the European Space Agency Ministers' conference will look at the long-term programme, which will obviously be important for European space programmes for the next couple of decades.

The European Space Agency is now producing positioning papers and it is important that the UK participates not only in the ministerial but in the preparatory work. Without the assurance of a modern national space programme, the UK will, at best, be able only to react to other proposals. Until now we have depended heavily on ESA and if we are to ensure that the ministerial meeting approves programmes that are useful to the UK, we need to be active in defining what we want to achieve from space activities.

The policies that we laid down in 1988 and the funding level are not producing the results that we intended, and there is evidence that they could even be damaging the chances of our space industry becoming competitive in a very competitive market. It is also urgent because we now have to take into account important new players in the European space scene, particularly the European Commission which has a potentially significant new role both as a user of space systems - Earth observation is just one example - and, complementary to ESA, to help European industry benefit from large new marketing opportunities in, for example, navigation.

ESA was set up some 30 years ago to create a European space industry and to ensure that Europe could gain a foothold in an area that was then dominated by the space war between the USA and the USSR. Until the mid-1980s ESA was a great success. It helped to establish the European communications satellite industry, notably in the UK, which led to the creation of Inmarsat and Eutelsat, both of which were originally based on ESA satellites. It also provided the basic industrial infrastructure leading to the successful military communications satellites of which the latest Skynet 4 version has been bought by NATO in preference to US military satellites.

ESA also led in the production of meteorological satellites which are the basis of Eumetsat and the daily pictures on TV weather reports. Those technologies have led to the new generation of Earth observation satellites, especially ERS 1 with its all-weather observation capabilities for which the radar was developed in the United Kingdom. ESA also has highly regarded international scientific programmes for astronomy and solar system science in which the United Kingdom's scientific community and our industries play an important role. For example, the space probe Giotto was built in the UK.

I am sad to say that the UK took only a small part in the final ESA success, the Ariane launcher. I say "sad" because Ariane is now winning over half the commercial launches that are put out to global competition. That success is bringing considerable benefit to the industries in those countries that decided to take a share. Since we use Ariane launchers for Skynet and pay a share of the cost of the launches that are required by ESA, we are contributing to work which largely goes to benefit space industries in countries other than our own.

However, I must not fail to acknowledge our contribution to the manufacture of the very accurate guidance system for Ariane and also the SPELDA system that separates the satellites as they are released into space. These are impressive British accomplishments. During the 1980s ESA decided to pursue a policy of seeking full autonomy in space for Europe and particularly for man in space, an aspect on which we have relied on US cooperation. The programme that was decided upon included continuing cooperation with the United States through the newly proposed space station in which Japan and Canada were also to be partners. But autonomy in putting man in space was to be achieved through an ambitious space plane - Hermes. Furthermore, this was to be achieved by the year 2000.

That ambitious programme was approved at the ESA ministerial meeting in The Hague in 1987, notwithstanding the fact that it required a doubling of the ESA annual budget. The UK refused to join on the ground that it was an expensive endeavour to achieve what the USA and the USSR had achieved 20 years earlier. In the aftermath of the demise of the USSR and one or two dramatic failures in the NASA programme, especially the failure of Challenger, money for space activities was put under more political scrutiny both in the United States and in the European countries. NASA has had difficulties in funding the international space station even with the new involvement of Russia. ESA Ministers found the escalating costs of ESA and especially Hermes unacceptable. Consequently, ESA has abandoned Hermes and is seeking a programme within, at best, level funding which Ministers might approve next year.

I have outlined that to show that ESA has served Europe well, but that it now appears to have lost its way in the prevailing political circumstances. Since we have funded most of our space activities through ESA, the uncertainties surrounding the programme and its direction is damaging to us and to our industries. That is why I am encouraging my right hon. Friend the President of the Board of Trade and our new Minister to renew interest in ESA and to help to seek a new role that will suit our purposes as well as those of the rest of Europe.

Due to our perceived attitude to space, the United Kingdom has lost much of its influence, not only in ESA, but in all parts of the world. That does not affect only the British National Space Centre; the effect inevitably rubs off on British industry, too. More to the point, the fact that we have placed a ceiling on expenditure, which is committed for the next few years, means that we cannot join the new programmes, except, possibly, at a derisory level. That is bound to be damaging to our industries and is hardly likely to leave us in an influential position of forming new ESA policies, if we cannot participate.

I shall mention just three cases in point. We cannot join the new ESA communications technology programme, even though our industries are prepared to contribute 50 per cent of the funding themselves - unique in Europe. We are offering a very small contribution to the ESA share of the second generation meteorological satellite, which will damage our industries' chance of taking part in the operational programme, for which satellites will be needed for the next 20 years. ESA is starting to examine the next century's generation of launchers, in the Festip programme, in which our ideas on the horizontal take-off and landing launcher or alternative systems have been world leaders. A share in that would be of major benefit to our capabilities in the areas of advanced materials, avionics, software and to all markets in which we presently have some eminence. If we cannot participate in all those programmes, we shall severely damage our

COMMENT

Space Policy Needs Urgent Review

The International space scene has changed dramatically since 1988 and European countries, through ESA, have the potential to play a major role in new space developments and to plan programmes extending well into the 21st century.

ESA has developed a major space launcher capability with the Ariane series of launch rockets, the latest version, Ariane 5, being scheduled for its first commercial launch in 1996. ESA is also actively preparing for the post Ariane-5 era with FESTIP, its Future European Space Transportation Investigations Programme. Due to government space policy, UK industry has not been able to participate in this work at more than a minimal level.

ESA has an active manned space programme and will be sending its first astronaut to the Mir space station in October 1994. ESA is a partner of the International Space Station and a major contributor with the Columbus Attached Laboratory. Due to government space policy, there is no UK contribution to ESA's manned space programme.

With these and other new developments on the European space scene, the UK is becoming increasingly marginalised to the detriment of its industry and technology base. A compelling case for an urgent review of UK space policy was made to the House of Commons by Mrs Cheryl Gillan MP on 21 July.

The reply by Mr Ian Taylor MP on behalf of the government makes depressing reading and lacks assurances to indicate that adequate positive thinking is in hand. This lack of government awareness and leadership is unsatisfactory for the UK space industry, for new space science and technology initiatives and for the country as a whole.

As a new space minister, Ian Taylor should now look at first hand into the problems that face the UK space industry, in both the immediate and longer-term future, and he should see that opportunities for this country to benefit from the developments of space are not lost.

The ESA ministers' meeting in September 1995 and the forthcoming preparatory meetings add all the more to the urgency of the matter.

competitiveness and, perhaps, the existence of the many capabilities which our ESA contributions have helped us create over the years.

The situation is made worse by the fact that the modest national programme, which the Department of Trade and Industry has always funded to help our industries to achieve success in the applications market, is being seriously eroded over the next few years. The space industry is no longer what we instinctively think - or rather thought - it to be. Its constituency has widened, so that many companies, such as those in the service industry, now use space as one component in their portfolio of activities. They will not be able to operate successfully unless there is some judicious, planned and sustained Government direction and investment.

It is often said that industry is primarily responsible for making itself competitive. I know that our own industry accepts that challenge, but in partnership with Government, as I have outlined. This week, we have seen the merger of our largest companies, Matra Marconi and British Aerospace Space Systems, bringing together their complementary capabilities, which will put the single company in a much better position to compete effectively. I welcome that change, but recognise that we have smaller companies with space capabilities, such as those represented by ASTOS, based in my constituency. Those companies also need to understand the sense of purpose in Government policy if they are to thrive. It is, after all, the smaller companies that are likely to achieve the growth in jobs which we all want to see as one of the products of our space policy. A rethink of space policy on what we want to achieve and how we want to achieve it is necessary and necessary now. The policies of 1988 may have been right then but they do not seem right now.

I mentioned earlier the entry of new players on the space scene. When I visited Brussels last week, with colleagues from the parliamentary space committee, we were delighted to hear how the Commission has come to recognise that there are a number of things which it can do to help European industry to achieve benefit from space activities.

The Commission is making progress in reaching agreement in Europe on satellite navigation. In that area, there are massive opportunities for our industries; airlines, ships, cars and lorries. Europe has a strong involvement at present in satellite navigation systems and we need to ensure that we at least maintain that position and that we do not lose out to the United States or Japan in the future.

There are other areas requiring Commission involvement, negotiating for a level playing field for our satellite industries and for the Ariane launcher; regulation of satellite communications in Europe; and negotiating, especially with the USA, on future mobile systems. Those would be useful negotiations which require action at a European level.

I hope that I have given the House the flavour of my argument - we have an urgent need to review space policy. We have important interests to protect and some exciting new fields to explore and exploit. Our level of funding for national programmes and our contributions to ESA should not be related to some historical level of funding. At the international level, and especially in ESA, we need to show how our policies of favouring space applications, with which many countries have come to share, can bring benefit through the adoption of market-led policies. At the same time, we need to support our industries where they face competition, not least from United States companies, which have received support from their own Government. In due course, we may be able to persuade other Governments to reduce their support, but I am afraid that we are not there by a long way yet.

Space is no longer the sole province of the space enthusiast, although I hope that those enthusiasts will continue to point the way not least for our children, for whom space is a great incentive to study science and technology. I have tried to indicate some of the economic and social benefits which space activities may bring to Earth. With the fresh thinking in other countries, it is the right moment for us to review our policies and re-engage in international planning for space activities, which can achieve our objectives. It would be a great pity if the 25th anniversary of the Apollo landing also heralded the abandonment of space by the UK because of its apathy towards policy and future planning and expenditure.

* * *

In reply Mr Ian Taylor MP referred to the following areas of UK space activities and policy:

International Cooperation

We in Britain can take justifiable pride in the contributions that we have made to the Hubble Space Telescope. It reminds us of the high regard in which our space science is held world wide. We have an industry of which we can be proud.

We have also played our part in the European Space Agency's Ulysses mission. There are other examples of course. In 1985, United Kingdom industry led the development of the Giotto mission to intercept Halley's Comet. It was also United Kingdom industry which primed all ESA's satellite telecommunications mission which have flown so far.

Our major contribution to Earth remote sensing satellites has provided - it will continue to do so - a wealth of data about the Earth and the development of its environment.

An important feature of these achievements is that they are possible through our collaboration with other nations in pursuing space activities. It is clear that no nation - not even a super-power - can afford the cost of major space missions in today's economic climate. Cooperation is now the order of the day. In that sense, the space race between nations is over and the old rivalry has been merged into co-operative ventures. We have only

to have regard to the efforts to include Russian participation in the international space station to perceive how much progress has already been made in that context.

Commercial Competition

The other major change since the epic first steps on the Moon has been the emergence of an identifiable commercial requirement for space telecommunications, broadcasting, navigation and business services. Governments are no longer the only players in space, so our attention has turned to industry's need to be competitive in world space markets.

The House will be aware that the Government's White Paper on competitiveness was a result of extensive consultation with industry. The House will wish to be told that the British National Space Centre is this morning consulting a broad cross-section of United Kingdom space companies on the full range of issues raised in the White Paper, including further development of an export strategy which involves our embassies, export promoters, trade specialists and, of course, industrial managers and market specialists.

Over the past year, the BNSC has worked closely with companies and trade associations to agree a strategy for that sector of the space industry, taking account of business opportunities, perceived barriers to markets and realistic levels of resource.

Companies in the United Kingdom and elsewhere in Europe meet various forms of tariff and non-tariff barriers in international markets. The Government are already heavily engaged in reducing those barriers. We work closely with the European Commission on conditions of trade.

Civil Space Policy

The Government set out their civil space policy in a statement to the House in 1988, to which we have firmly adhered.

The priority objective of our policy have been, first, the development of Earth observation for environmental and long-term purposes. The second objective is to help industry to take advantage of past investment to make a commercial success of satellite communications and, where appropriate, to foster development of specialised telecommunications technologies. The third objective is the maintenance of a sound space science base.

ESA has undoubtedly been a source of many successful missions and developments in space technologies. The agency, with the United Kingdom as the lead participant, laid the foundations for today's thriving satellite telecoms sector. With the United Kingdom as major proponent, the agency is at the forefront of Earth observation. Our contribution to the ESA science programme has been and still is extremely successful.

Government-Industry Co-operation

Co-operation between Government and industry is very important. The BNSC is currently talking to ESA, Eurocontrol and the DTI about the next generation of air traffic navigation systems under the general heading of satellite navigation.

It is important to try to get industry to come forward with research and development money and to enable the United Kingdom contribution to ESA to be the broadest possible across Government and industry. I am satisfied that the present provision in the national programme covers the key essentials, particularly in relation to our prior objectives in Earth observation.

Our emphasis is, and will be, on value for money both in the conduct of ESA's operations and in encouraging the most cost-effective approach to the provision of all space and space-related services.

European Manned Space Programme

As events turned out, our decision not to take part in a European manned space programme was sensible, although, of course, it might have been exciting. The main planks of our space policy remains valid, and, indeed, other ESA partners are realigning their policies more closely with United Kingdom objectives. ■

British Aerospace Space Systems Acquired by Matra Marconi Space

On 19 July, British Aerospace agreed to the sale of its wholly owned subsidiary, British Aerospace Space Systems Limited, to Matra Marconi Space for a consideration of approximately £56 million. In the year ended 31 December 1993 British Aerospace Space Systems Limited had a turnover of £151 million.

The acquisition will consolidate the position of Matra Marconi Space as Europe's leading space company and largest satellite manufacturer. The new operational company will be in a position to offer the satellite market unrivalled experience and expertise. It will also expand its launchers and ground stations business.

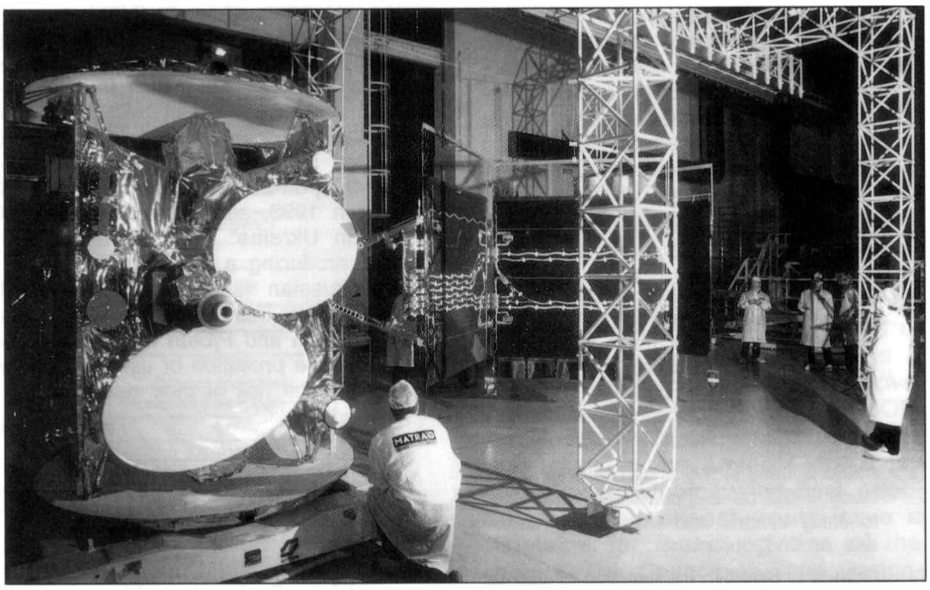
The order book of the new company will be $2 billion, with 37 major programmes spread over telecommunications, Earth observation, scientific experiments, launchers and ground control systems. With the addition of its European and overseas subsidiaries, Matra Marconi Space will be the world's third largest space industry group, strengthening the position achieved over the last two years.

Noël Forgeard, President of Matra Hachette and Chief Executive, Defense-Space sector. G. NOJAROFF

Space programmes on which Matra Marconi Space and British Aerospace Space Systems worked together include Skynet 4, Nato 4, Telecom 2, Hispasat, Inmarsat 2, Orion, Eutelsat Hotbird 2 and Envisat. Eurostar is Europe's leading spacecraft platform and has been selected for telecommunications satellites with over 8 satellites now in orbit.

In addition to its main French and UK operations, Matra Marconi Space has subsidiaries in the US, Spain, Belgium, Italy and Australia. ■

Telecom 2 satellite in the test facilities at Matra Marconi Space, Toulouse. G. NOJAROFF



COSPAR '94: 30th Scientific Assembly

The COSPAR Scientific Assembly - an international meeting of some 2,000 scientists - is organised every two years. In 1992, Washington DC welcomed it in the framework of the Space Congress. In 1994, the German city of Hamburg organised a very successful conference of scientific achievements in space and an exhibit of space science. The meeting was marked by the 25th anniversary of the first manned lunar landing and by the cometary encounter with Jupiter.

Two star events at the Assembly were the description by former astronaut Jack Schmitt, the 12th (and last) man on the Moon of the impact of the Apollo programme on the Earth sciences and the performance of the Russian Marsokhod rover, now planned for a Martian mission in 1998-1999.

Lectures at the COSPAR meeting concerned mainly the environment of the Earth, from the ground to the magnetosphere, as well as new observations in the Solar System. The planet Mars appeared to be the most attractive element to be explored during the next decade with missions of the USA, Russia and Japan. The return to the Moon would become an international project with Europe taking a leading position.

A report from COSPAR '94 on forthcoming Mars missions appears on p.315. Other selected news items from COSPAR '94 are given here.

Atmospheric Studies

The Swedish Space Corporation, with an increasing annual budget for space science and technology ($92 million for 1993-94) is developing small spacecraft and payloads mainly for studies in magnetospheric, ionospheric and atmospheric physics. Three satellites are in preparation as successors of Viking (launched by Ariane 1 in February 1986 and operated until May 1987) and Freja (launched by Long March 2 in October 1992 and still active):

- Astrid 1 will be the first Swedish microsatellite to be launched in 1994-95 by a Russian rocket. Total mass is about 20 kg. Its payload consists of instruments to measure neutral particles and electrons in the magnetosphere and of UV photometers to image the aurorae.
- Astrid 2 - still in the phase of preliminary study - will be launched one year later to study electric and magnetic phenomena around our planet.
- Odin is a Swedish minisatellite of 200 kg to be launched in 1997 for an operational lifetime of two years. It will carry a payload for spectroscopic studies at submillimetre and millimetre wavelengths of astronomical objects and processes in the atmosphere of the Earth. Odin, designed to serve both astronomy and aeronomy, is being carried out as an international programme with Canada, France and Finland.

Space Solar Telescope

Beijing Astronomical Observatory has proposed to the Chinese Academy of Sciences a Space Solar Telescope with an orbital mass of some 2.5 tons, for an orbital lifetime of 3 to 5 years. Its payload would consist of an optical diffraction limited telescope with 1-m diameter, a 2-D real-time polarising spectrograph and four attached small telescopes of UV, hard X-ray, soft X-ray and full disk.

The present planning calls for a launch with a Long March 4B in 2001-2002, just in time for the next solar maximum. It will be placed in Sun-synchronous polar circular orbit at 500-km altitude. Recently completed by a staff of 25 scientists and engineers, a one-year feasibility study showed the technical capability of China to develop this orbital telescope.

Orbital Debris

The former USSR and CIS successfully launched 2,320 launch vehicles to place in orbit 2,750 spacecraft in 38 years of satellite launch activities from 1957 to 1993. This statement was made during the 30th COSPAR Scientific Assembly by Russian engineers working at Kaliningrad, the "space city" of Russia, in the Northern part of Moscow. This represents a yearly rate of some 60 launches. More than 1 per week!

84% of the 2,750 spacecraft were injected into orbits of up to 2,000 km altitude, while 12% were placed in highly-elliptical - Molniya-type - and geostationary orbits. Upper stages of launch vehicles have led to almost half the debris presently in near-Earth space. The report presented by the Russian engineers revealed that, on 26 December 1992 and on 27 March 1993, spent second stages of "made in Ukraine" Zenith vehicles exploded, producing a lot of orbital debris.

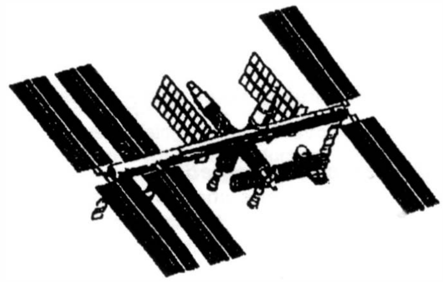
The Russian lecture also described improvements being developed for the Soyuz, Zenith and Proton launch vehicles to reduce the presence of used stages in space and the risk of their disintegration.

THEO PIRARD

Satellite Testing

Intespace, a European specialist in space environmental techniques, announced from Toulouse on 11 July that it has won two contracts for testing two satellites under space environmental conditions:

- Italsat 2, manufactured by Alenio Spazio (prime contractor) on the behalf of the Italian Space Agency (ISA), is a telecommunications satellite scheduled for launch by Ariane in 1995;
- Amos, manufactured by Israel Aircraft Industries (prime contractor) on behalf of the Israeli government, is a telecommunications satellite scheduled for launch by Ariane in 1995.



Space Station Assembly Sequence

A revised assembly sequence was approved on 12 July that provides significantly more power for the United States laboratory at the International Space Station.

Space Station officials began work on a revised assembly sequence several months ago to address Administration and Congressional concerns about power and US capability to provide redundancy for critical on-board systems early in the assembly sequence.

The revised assembly sequence reduces risk by relying on a well defined US photovoltaic array module to provide electrical power for the Space Station. This increases from eight to 13 kW the average maximum power that is available to the US laboratory when it is delivered to the Space Station, an improvement that is critical to the user community as some high power experiments may now be flown earlier.

In addition to agreeing to the improved assembly sequence, the Space Station Control Board (SSCB) concurred with plans to purchase the power and propulsion module known as the "FGB" or "energy block" from Russia's Krunichev enterprise. Purchase of the FGB, at a price to be negotiated, assures its availability at the outset of Station assembly and adds redundancy in guidance, navigation and control and reboost capability.

The Board also baselined an assembly sequence that includes ESA's plans to launch its attached pressurised laboratory module on Ariane 5 instead of the Space Shuttle. The board is comprised of Space Station programme management, international partners and Boeing Space Station team management.

Quality Imagery Gets Saudi Partner

Eyeglass International, a US consortium and EIRAD Co, a Riyadh-based space technology firm, plan "a major business arrangement" involving the distribution of satellite images sharp enough to show objects on the ground as small as 1 m across. The planned deal would develop, build and operate a remote-sensing satellite system and provide detailed satellite imagery to customers worldwide. Such images, once available only from spy satellites can now be marketed by US companies after long opposition from the Pentagon. Eyeglass plans to have its system operating by early 1997.

STS-65: Columbia Launched on Time

The Space Shuttle orbiter Columbia was launched on time from the Kennedy Space Center at 12:43 pm on Friday, 8 July 1994 with a crew of seven astronauts and the IML-2 (International Microgravity Laboratory-2) payload.

Prelaunch Processing

Columbia returned to the Kennedy Space Center from its STS-62 mission on 18 March 1994. It was rolled into the Orbiter Processing Facility work bay 2 on the 19th and began reconfiguration from the STS-62 mission to the STS-65 flight which was scheduled to last from 8 to 22 July.

IML-2 consisted of a Spacelab connected to Columbia's middeck area by a personnel tunnel/passageway. Columbia utilised the Extended Duration Orbiter pallet containing additional supplies of fuel cell reactants in order to support the lengthy stay in space.

Columbia remained in the OPF until 8 June while undergoing routine preflight processing, including the installation of the STS-65 main engine set and the International Microgravity Laboratory-Two which was the primary payload for the mission.

Following the installation of IML-2 on 9 May, a test was conducted to insure that the interfaces between the payload and the orbiter were satisfactory and the pressurised tunnel which connects the IML-2 to Columbia's middeck was correctly in place. Following stowage of equipment in the IML-2 module in late May and the closing of Columbia's payload bay doors on 4 June, Columbia and its payload were moved to the Vehicle Assembly Building.

On arrival there on 9 June Columbia was rotated to a vertical orientation on its Mobile Launch Platform for mating with the Solid Rocket Boosters and External Tank. After interface checks between the orbiter and the other components the entire Shuttle was moved to Launch complex 39A on 14 June where it underwent interface checks to validate connection with the launch pad. A practice launch countdown was held on 21 and 22 June, manoeuvring system propellants were loaded and pressurised, pyrotechnic systems checked and late access IML-2 stowage was accomplished in readiness for the countdown.

Countdown and Launch

Countdown began at 6:00 am on 5 July with the clock at T-43 hours. A series of built-in-holds over the next several days would bring the countdown to a planned T-0 at 12:43 pm on 8 July.

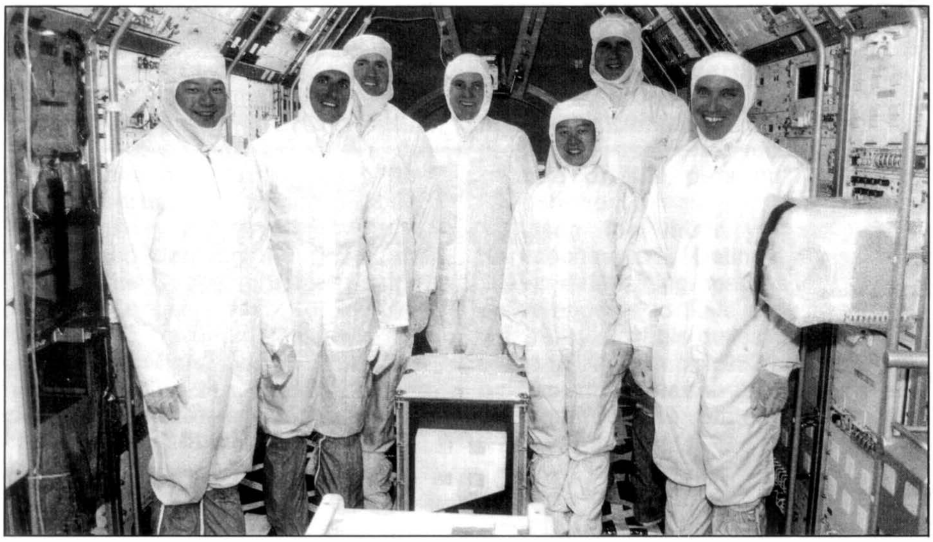
The countdown proceeded without difficulty. The crew left KSC's Operations and Checkout Building and shortly before 10:00 am arrived at Launch Complex 39A and began their orbiter entrance operations. The crew hatch was closed at about 11:13 am.

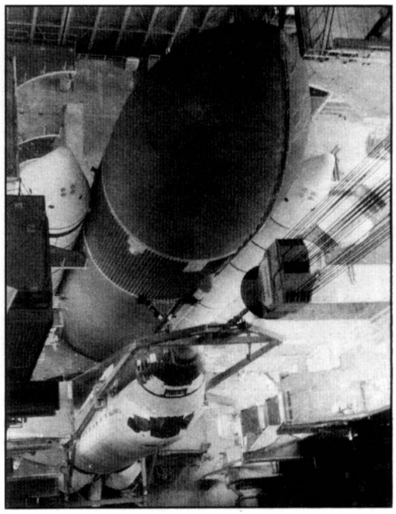
The final hours of the launch countdown were accomplished with a close eye on the weather as during July the launch area has a high rate of thunderstorms and rain activity. However the weather was within limits as the T-0 point approached and no unplanned holds were necessary. STS-65 was launched on time at 12:43:00.069 pm on 8 July 1994.

As the Shuttle cleared the launch complex tower it began a programmed roll and arced upward towards its 28.45 degree angle of inclination orbit. Following the Solid Rocket Booster burnout and separation at 2 minutes and 4 seconds into the flight, Columbia's main engines continued to burn until cutoff at 8 minutes 39 seconds into the mission. At 42 minutes and 22 seconds after liftoff the manoeuvring engines completed their approximately 2 minute 26 second burn to place Columbia in its orbit of 160 by 163 nautical miles.

Details of in-orbit activities will appear in a forthcoming issue of ***Spaceflight****. A major part of the scientific investigations and hardware for the IML-2 mission were provided by ESA.*

The flight crew in the IML-2 Spacelab module during Crew Equipment Interface Test (CEIT) operations in Orbiter Processing Facility high bay 2 on 20 May. From the left are: Leroy Chiao, Donald A. Thomas, James D. Halsell, Robert D. Cabana, Chiaki Mukai, Richard J. Hieb and Carl E. Walz. NASA





An unusual view of the Shuttle, seen here in the Vehicle Assembly Building. The orbiter Columbia is being mated with the External Tank and Solid Rocket Boosters in readiness for launch on mission STS-65. NASA

About the Crew

The crew was divided into two teams for 24 hour work coverage. The "red" team consisted of Robert Cabana, James Halsell, Rick Hieb, and Chiaki Mukai. the "blue" team was made up of Carl Walz, Leroy Chiao and Don Thomas.

The Commander of the STS-65 mission was ***Robert D. Cabana***, 45, Col., USMC. He was selected as an astronaut in 1985 and this was his third space flight. He served as Pilot on the STS-41 mission to deploy the Ulysses planetary probe in October 1990 and also as Pilot on the STS-53 Department of Defense mission in December 1992. He had logged over 273 hours of space flight time prior to STS-65.

The Pilot for STS-65 was ***James Donald Halsell, Jr.***, 37, Lt. Col., USAF, who was selected as an astronaut in 1990. STS-65 was his first space flight.

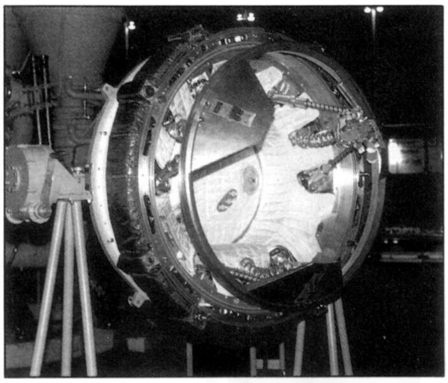
Payload Commander and Mission Specialist-One was ***Richard J. Hieb***, 38, who was selected as an astronaut in 1985 after having worked at the Johnson Space Center in crew procedures and activity planning. STS-65 was his third space flight as he had previously flown as Mission Specialist on STS-39 in May 1991 and on STS-49 in May 1992. During the latter mission Hieb performed three spacewalks in support of repair operations on the Intelsat VI F3 satellite. He has logged over 400 hours of space flight time on his previous missions.

Carl E. Walz, 38, Lt. Col., USAF was Mission Specialist-Two and was making his second space flight having been selected as an astronaut in 1990. His first mission was as Mission Specialist on STS-51 in September 1993 and he had over 236 hours of space flight experience on that mission.

Leroy Chiao, PhD, 33, was Mission Specialist-Three for the flight. He was selected as an astronaut in 1990 and STS-65 was his first space flight.

Donald A. Thomas, PhD, 39, was Mission Specialist-Four and he was also making his first space flight having been selected as an astronaut in 1990.

Payload Specialist-One was ***Chiaki Naito-Mukai***, MD, PhD, 41. She was selected as a science astronaut by the National Space Development Agency of Japan in 1985 and STS-65 was her first space flight.



The universal docking system to be used for the joint mission of Space Shuttle and Mir. Th.P./SIC

Shuttle-Mir Revision

Only seven Shuttle-Mir docking flights are listed in the KSC Shuttle Status Report of 29 July 1994 and they are all Atlantis flights. The schedule is as follows:

Mission Mir	STS	Vehicle	Launch
			1995
Flyby	63	D	02 Feb ± 8d
01	71	A	30 May ± 10d
02	74	A	26 Oct ± 6d
			1996
03	77	A	20 Mar ± 10d
04	80	A	31 Jul ± 10d
05	82	A	05 Dec ± 10d
			1997
06	85	A	15 May ± 10d
07	87	A	11 Sep ± 10d

The proposal to reduce the 10 Shuttle docking missions to Mir to seven has previously been made in order to reduce costs and it seems that three flights have now been eliminated.

Up to 10 veteran NASA astronauts were to spend a year in Russia training for up to five long-duration stays aboard Mir between 1995 and 1997. The training is in two-person teams (a prime and backup candidate). Current plans envisioned two three-month stays and three six-month stays aboard Mir. One of the five long-duration stays may now be cut.

Norman Thagard and Bonnie Dunbar are already training in Zvezdny Gorodok. The next two-person team is scheduled to fly to Russia in January 1995 with succeeding teams arriving in April and October 1995.

It is not yet certain how the reduction in flights will affect the number of US astronauts that will fly on Mir. A. VAN DEN BERG

Third Launch in Two Months

During the night of 10-11 August, Arianespace successfully launched two satellites: Brasilsat B1, Brazil's first second-generation satellite and Turksat 1B, Turkey's first telecommunications satellite.

The launch vehicle for Flight 66 was Ariane 44LP, the European launcher equipped with two liquid-propellant and two solid-propellant strap-on boosters. Liftoff was from the Space Center in Kourou, French Guiana.

Brasilsat B1 is the first model of the second-generation satellites built by Hughes Space and Communications at El Segundo, California, on behalf of EMBRATEL of Brazil. Weighing 1,765 kg at launch it is equipped with 28 C-band transponders. It will be positioned over Brazil and provide telecommunications services for that country.

Turksat 1B, Turkey's first telecommunications satellite, was designed and will be delivered into orbit by Aerospatiale. Built in Cannes, France it weighs 1,779 kg and is equipped with 16 Ku-band transponders. Positioned in orbit over Somalia, it will provide telecommunications, television and data transmission for Turkey and the Turkish-speaking communities in Europe and Asia.

The next launch, Flight 67, is now scheduled for September 8, 1994, when an Ariane 42L launch vehicle will be used to place into orbit the Telstar 402 telecommunications satellite for AT&T of the United States.

ORFEUS Reaches for the Stars

A second scientific mission with the ORFEUS-SPAS (duration: 10-14 days) is planned for August 1995.

ORFEUS is a binational project (DARA/NASA) in astronomical ultraviolet spectroscopy. In order to understand the life cycles of extremely hot stars, physical parameters of density, temperature and mass transfer rates during cooling periods of white dwarfs or supernovae are to be measured. Responsibility for the system lies with Kayser-Threde GmbH. The telescope is integrated in the autonomous, reusable scientific satellite ASTRO-SPAS. After 144 hours of scientific observation the ORFEUS-SPAS is retrieved and brought back to Earth.

Chinese Launches

On 3 July, China launched a recoverable research satellite with a Long March 2D rocket into its correct orbit. It will orbit for half a month conducting scientific surveys of the Earth's surface and on-board experiments on animal cells and industrial applications. Results will be transmitted back to Earth or recorded on the satellite for analysis after it has returned from orbit.

On 21 July, APSTAR 1, an HS 376 communications satellite, was successfully launched from the space centre in Xichang, Sichuan Province, in southwestern China. It was the fourth launch of a Hughes-built satellite on a Long March rocket.

The satellite was built for APT Satellite Company Ltd of Hong Kong and is the first of two spacecraft ordered by them from Hughes. It carries 24 transponders in C-band to provide voice, data and broadcast services to mainland China, Hong Kong, Indonesia, Japan, Singapore and Vietnam. The second satellite launch, an HS 601 model, is scheduled for December.

This is Hughes' busiest launch year ever with 13 spacecraft due for launch by December. Four have been launched so far.

German-Chinese Company

"EurasSpace" is the name of a company founded by Deutsche Aerospace AG (Dasa/Munich) - represented by its Satellite Systems Division (Munich/Friedrichshafen) - and China Aerospace Corporation (CASC/Beijing) on 8 July.

EurasSpace will undertake development, production and marketing of communication and Earth observation satellites with the related ground facilities.

As a result of the economic reforms of the People's Republic of China, CASC emerged as a company with private legal structure and as early as September 1993 an agreement was signed with the aim to found a joint company.

The first satellite project of the new space technology company will be a communications satellite, Sinosat-1, with the option for two follow-on units - for a Chinese operator. This first customer will be the Sino-Satellite Communications Company Ltd in Beijing providing services for the Peoples Bank of China.

China and Hong Kong are expected to have a combined demand for approximately 20 spacecraft in the next ten to twelve years.

DC-X Damage Explained

It was the detonation of fuel cloud vapours that resulted in damage to the Delta Clipper Experimental (DC-X) single-stage launch vehicle during the 27 June flight test.

An investigation committee has determined that a cloud of free-vented gaseous oxygen, gaseous hydrogen and water vapour, which normally forms at the base of the DC-X during the engine prestart phase, was ingested into the air purge duct which is a part of the DC-X's ground support equipment. Video records indicate that the cloud stayed close to the ground during the 27 June flight and did not rise as in the past. In fact, the cloud travelled along the ground and was ingested by one of two venting system air ejectors located in a utility trench at the flight pad.

During the pre-launch phase, the ejectors, 12-inch diameter, 25-foot long pipes, continuously blow air to prevent the accumulation of hydrogen and oxygen under the vehicle. At engine start the gaseous mixture inside the ejector pipe was ignited and the detonation occurred.

In turn, the detonation caused the cloud of vented gaseous oxygen and hydrogen to burn quickly creating a pressure wave. The pressure wave forced the flat external side of the DC-X's graphite composite epoxy aeroshell inward toward the aluminium core structure. Pressure was reversed as the pressure wave passed, pulling the aeroshell outward. Additionally, normal atmospheric pressure, trapped between the aeroshell and the aluminium core structure, along with the lower pressure caused the damaged section to bulge and rip outward.

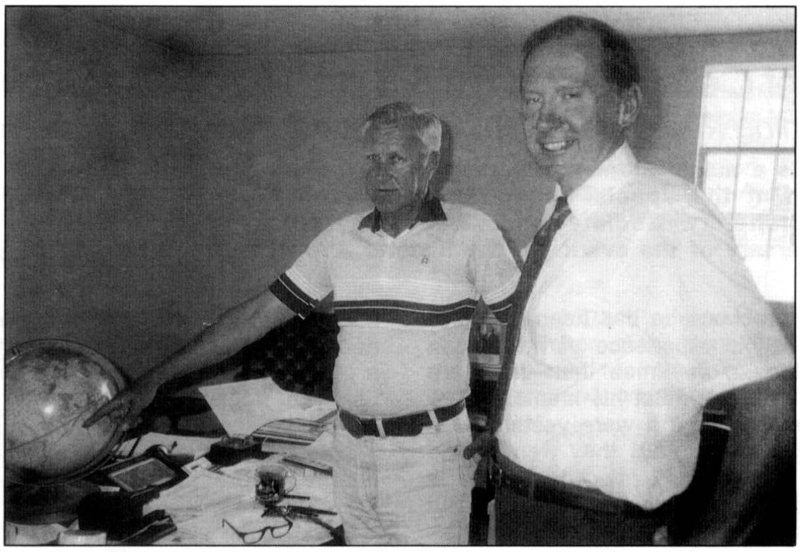
Despite a 4 by 15-foot vertical tear in the aeroshell during takeoff, the DC-X executed a safe landing on the desert floor. All systems were operating normally throughout the 78-second flight. Seventeen seconds into flight, the DC-X's "autoland" command was activated and cancelled the previously planned flight manoeuvres. The DC-X then automatically completed pre-planned emergency landing sequences.

Ariane 5 Solid Booster Test

On 20 June the third test on a P230 solid booster for the Ariane 5 launcher took place on its test stand at the Guyana Space Centre. The first indications are that the test went well.

This test (M3) follows the M1 test which took place on 25 June 1993 with the booster in "near-flight" configuration, whereas the M3 test was carried out in "flight" configuration. Four more tests are foreseen before the maiden flight of Ariane 5 (Ariane 501) in late 1995.

The Ariane 5 launcher will be fitted with two P230 boosters, each 30 m high and containing 237 t of propellant grain in three segments. Each booster has a thrust of 540 t, which makes it the most powerful booster ever built in Europe.



Bob Davis, President of EPAC, shows on the globe the location of the Ascension Island, on the equator, in the middle of the Atlantic Ocean, a proposed launch site for Eagle vehicles. Th.P./SIC

Eagle Series Space Launch Vehicles

On 29 June, E'Prime Aerospace announced the introduction of the Eagle Series of satellite launch vehicles which will reduce the cost per pound of payload into orbit by 50% compared to present launch vehicle systems. This cost saving is realised by utilising a much simpler vehicle which in turn requires a much simpler launching system.

The Eagle launch vehicle will be launched from Ascension Island for geosynchronous communication satellites and from Vandenberg Air Force Base, California for polar orbit satellites. Tests to verify the Eagle Series launch systems integrity will be conducted at Vandenberg Air Force Base this summer.

Further details are due to appear in a forthcoming issue of ***Spaceflight.***

Inmarsat's Extra Satellite

Inmarsat will order a fifth, US$80 million Inmarsat-3 satellite from Martin Marietta to ensure adequate capacity for its present and planned future mobile communications services. Should all five launches lead to successfully operating spacecraft, the fifth could be an in-orbit spare or provide a fifth coverage region.

Like the four Inmarsat-3 satellites already on order, the new spacecraft will enable Inmarsat to use the increased power and capacity of spot-beam technology to provide services to the rapidly-growing number of users worldwide and to reduce the size, weight and cost of mobile terminals. Inmarsat-3 will also be the first commercial satellite system to carry navigation payloads.

Launches of the current Inmarsat-3 series satellites, now under construction by US contractor Martin Marietta and European Matra Marconi Space, will begin in late 1995. The fifth satellite will be delivered in 1997. Proposals to launch Inmarsat-3 F5 will be solicited from Arianespace, General Dynamics and DB Salyut/Krunichev. Orders have already been placed for two Inmarsat-3 launches by Atlas Centaur, one by an Ariane and one by a Proton.

Russian-Kazakh Mission

Soyuz TM-19 was launched from Baikonur to Mir on 1 July with cosmonauts Yuri Malenchenko of Russia and Tolgat Mussabayev of Kazakhstan on board and docked with the space station two days later. It is the first time that two cosmonauts on their first space mission have been launched alone. The two cosmonauts, Viktor Afanasyev and Yuri Ussachyov, are to return to Earth after 6 months in space. The new crew is to work for four months with scientist Valeri Polyakov who wants to set a new record of time spent in space at 427 days.

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
1994					
STS-64	September	Discovery	9 Days	LITE, GBA	57.0
STS-66	Late October	Atlantis	10 Days	Atlas-3, Crista-SPAS, SSBUV/A	57.0
1995					
STS-67	January	Endeavour	13 Days	ASTRO-2	28.5
STS-63	February	Discovery	8 Days	Spacehab-3, Spartan-204, CGP/Oderacs-2	51.6
STS-69	May	Endeavour	10 Days	Spartan, WSF	28.5
STS-71	May	Atlantis	9+1 Days	Mir-01 Mission	51.6
STS-70	July	Discovery	5 Days	TDRS-G	28.5

Society News

25th Anniversary of Apollo 11

Joint Celebration by BIS and Cray Electronics

Evening Reception Welcomes Guest of Honour, Buzz Aldrin

"It was a magic moment stepping on to the surface", said astronaut Buzz Aldrin at the special reception in London organised by The British Interplanetary Society and Cray Electronics to commemorate the anniversary of the events of the historic Apollo 11 Moon landing 25 years ago.

Buzz reckons he has been asked to describe his experience of walking on the Moon more times than there are stars in the sky. But his memories are still as vivid as if it were yesterday.

"Anyone who says they went to the Moon and it didn't affect their lives is certainly looking the other way". But according to Buzz it was not necessarily the thrills of launch, walking on the Moon or looking at the Earth from a distance of a quarter of a million miles that had the most impact. "We came back to people who had a different perception of us. They looked at us in a different way and that was probably the most difficult aspect," he said.

Now aged 64 and one of the most active former Moon walkers in supporting today's space programme, Buzz Aldrin stepped on to the lunar surface in the shadow of mission commander, Neil Armstrong. "I suppose it was based on seniority. My mission was to follow Neil out and that is what we had trained for", he said.

The first Moon walk was one of the great landmarks in history and most people in their early thirties and above can recall where they were as the astronauts landed. "When people find out who I am, I cannot tell you how many automatically volunteer the information as to what they were doing at that moment. They want me to know", he said.

"I have wondered what that really means. There was a cost in going to the Moon, but there was also a value. I think it has a lot to do with the millions of lives that were changed - so much so, they value that moment strongly, through a sense of participation".

Life in the past quarter century has not always been kind to the former astronaut. He reached "rock bottom" with depression and alcoholism but has conquered both and created a new life for himself with his third wife Lois.

Buzz believes that one day people will visit the red planet, Mars. "I wish I knew what spark would ignite the roller coaster to Mars. In the first place we need to do something about our launch vehicles, to make them bigger, cheaper and more reliable", he said.

Reflecting on how society has changed in 25 years he says our "capacity for wonder" has withered.

"Ironically, the view of the whole Earth from space has given many people a feeling that we should make our pilgrimage not outward to the stars but inward to meet the ever-present needs of humanity. There seems to be a growing retreat into the delusion of a risk-free society.

"But I believe that a well-rounded people must have both the humility to nurture the Earth and the pride to go to Mars".

Buzz began his address by showing a personal video entitled 'Apollo 11' and at the end of his address, he welcomed questions from the audience saying that he was always looking for something that he had not been asked before. A lively question and answer session followed.

* * *

Among the guests at the reception were many who had been involved in the exploration of space and several who had been directly involved in the Apollo 11 mission, including some of the Apollo engineering team.

On the platform with Buzz Aldrin were two who were closely associated with the Apollo 11 mission: *David Wilkins* who spoke about the 'Spirit of Apollo' and *Capt. Robert. F. Freitag* who spoke about the 'Management of Apollo'.

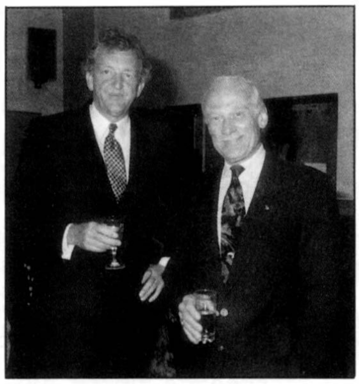
The proceedings were opened by the leading representatives of the two host organisations: *Martin Fry*, Vice-President, British Interplanetary Society and *Roger Holland*, Chairman, Cray Electronics. After the opening addresses a video message from Arthur C. Clarke was shown entitled 'A Journey Down Memory Lane' in which he recounted memories of Apollo and the occasions on which he had met the first lunar astronauts, Neil Armstrong and Buzz Aldrin, going back to the early days of the programme.

The following are extracts from the short addresses that were given.

Martin Fry

Vice-President, British Interplanetary Society

"None of us needs reminding that Apollo 11 was an historic event in the history of mankind, being man's first step on to another world - an event which can never be repeated. As I am sure most of you know, one of the missions of the BIS is to promote the benefits of space exploration, by dissemination of information to its members and others, through its publications, meetings, etc. It also encourages innovation by exploiting the unfettered imagination of its members, among whom are some of the brightest space scientists and engineers. In 1938-39 the BIS undertook a design concept for a lunar lander. It was never built, but the Apollo spacecraft was and the success of the Apollo programme proved to be a great inspiration to us. Tonight, we are here to celebrate this historic endeavour".



Roger Holland, Chairman, Cray Electronics and Buzz Aldrin.

Roger Holland

Chairman, Cray Electronics

"It is a great honour for Cray, and for me, to be associated with the celebration. Cray is the leading supplier of spacecraft software in Europe and we value very highly our association with the BIS.

I was involved in the Apollo 11 programme in a small way. I worked on the life support systems and was involved with the vibration testing of the LEM in Huntsville, Alabama. Space remains a prominent interest in my life.

Recently, I have watched the revival of TV documentaries of Apollo 11. A common theme was the new President, Richard Nixon, claiming the Apollo 11 voyage as the greatest feat of this millennium. Since that time space travel has almost disappeared from our consciousness.

I look forward to the day when we can again deliver the kind of commitment to success evident in the Apollo programme and we can regain the team spirit shared by the many thousands of people who worked on the project. Perhaps these are just dreams of days gone by. I hope not.

Today, on this 25th anniversary of Apollo 11, we must play our part to ensure that manned space travel becomes a reality once more. I am very proud to be associated with this vision".

David Wilkins

Manager, Gran Canaria Tracking Station

"I will always associate the Apollo 11 lunar landing with the island of Gran Canaria because I spent five years there as Manager of the NASA Gemini and Apollo Tracking Stations. I was on duty on 20 July 1969, at the time of the lunar landing and also in the early hours of 21 July when Neil Armstrong and Buzz Aldrin stepped down to the lunar surface. During those years the station was part of the Manned Space Flight Network and a vital element in the immediate post-launch activities.

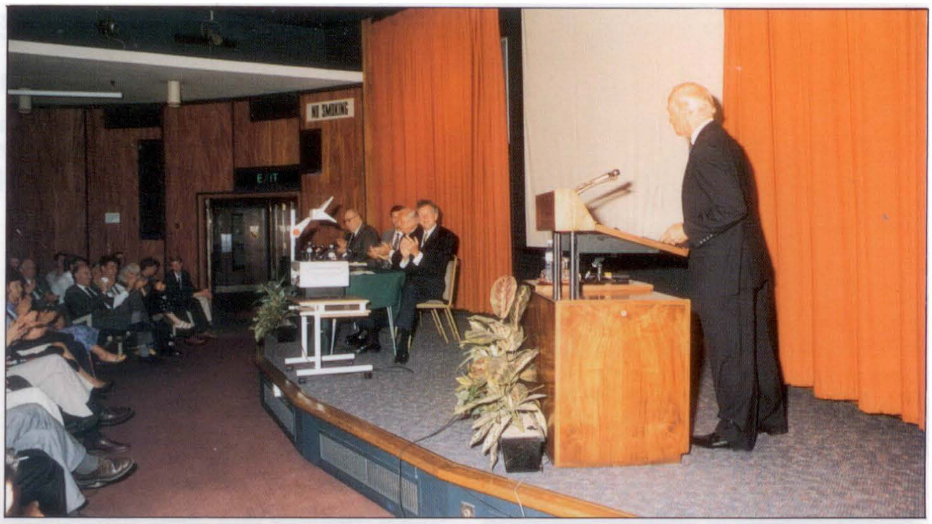
For those of us at the Gran Canaria station, Apollo 11 was the culmination of years of effort. The general reaction, after the splash-down of Apollo 11, was not just the sense of sharing a great accomplishment but the desire to get the next crew on its way to the Moon".

Right: **Buzz Aldrin receives a round of applause at the end of his address. He then invited questions from the audience.**

Below: **A capacity audience assembles for what proved to be a very enjoyable programme of presentations commemorating Apollo 11.**

Centre Column: **Fred Clarke, the brother of Arthur C. Clarke, greets Buzz Aldrin.**

Right Column: *(Upper)* **Martin Fry, Vice President BIS** *(left)* **with ESA astronaut Wubbo Ockels and his daughter;** *(Middle)* **Lawrence McGinty of ITN interviews Garry Hunt;** *(Lower)* **Lois and Buzz Aldrin with Shirley Jones, BIS Executive Secretary.**



Capt Robert F. Freitag

Director, Field Center Developments

"We in NASA have had a long and profitable relationship with the British Interplanetary Society. Another of our relationships with Britain, that is not widely appreciated, is the fact that there was a "British Team" working on Apollo for the full duration of the programme and that it was absolutely key to Apollo's success.

In the early 1950s, A.V. Roe set up a Canadian aircraft factory, primarily staffed by British engineers, to design and build the CF-105 fighter called Arrow. In early 1959, Prime Minister Dieffenbaker cancelled Arrow which caused 14,000 AVRO employees to be laid off.

At the same time, NASA was assembling the Space Task Group as the cadre for manned space flight programmes and were seeking top talent. Within a very few weeks, some 50 to 60 key British/Canadian engineers were recruited and moved to Langley Research Center in Virginia. These key engineers, approximately 25 percent of the initial team, were invaluable. Individuals like John Hodge, Jim Chamberlain, Rod Rose, Owen Maynard and others served vital roles throughout the decade.

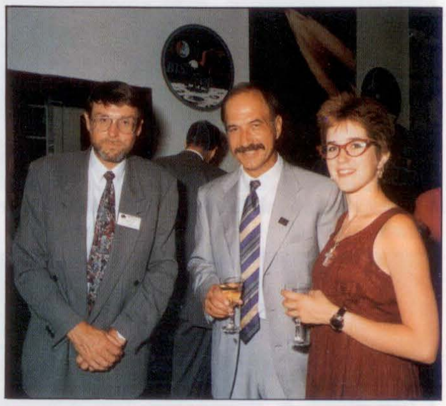
Apollo taught America, and much of the world, how to manage and execute large enterprises successfully. This experience will hold all of us in good stead for solving the great problems that the world will face in the future. The United States has consistently attempted to inculcate this experience and background into other nations of the world especially Europe, Canada, Japan and, most recently, Russia. Someday, we should all be able to sing from the same sheet of music and the world will be so much better for having enjoyed the fruits of Apollo".

* * *

The photos on pp.298-300 are provided by courtesy of Jozef G. Kneba, photographer.

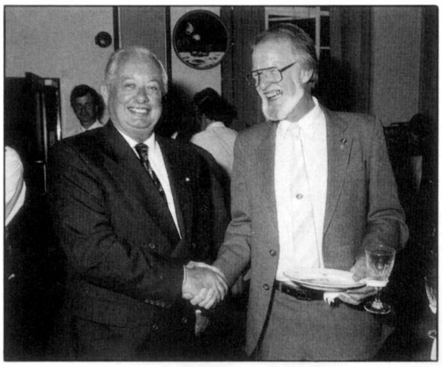
The assistance provided by Clive Simpson with administrative arrangements is gratefully acknowledged. In attendance at the event were representatives of ITN, Sky News and MTV.

The reception was held on 13 August at the Scientific Societies Lecture Theatre, London W1.



British Engineers and Scientists in the Apollo Project

The Apollo 11 25th anniversary has been an occasion for special celebration and reminiscence by those British engineers and scientists who were closely involved with the Apollo project over many years of preparation and the actual lunar missions.



David Wilkins and Keith Wright who were two of the British engineers involved for many years in the Apollo Project.

Patrick Moore with Prof and Mrs Garry Hunt.

Alan Bond and Richard Varvill.

BIS members meet Buzz Aldrin. On the right is John Perrin, FBIS.

***Keith Wright, FBIS** writes:*

I am particularly pleased that the Society has once again chosen to recognize the importance of the role which British engineers and scientists played in the Apollo project, something which, I was sorry to see, both the BBC and ITV chose to ignore in their recent programmes commemorating the Apollo 11 anniversary.

During the years of the Apollo programme, I was lucky enough to be a member of a small team of engineers and technicians who were responsible for the checkout and preparation of the Apollo lunar surface experiments package at the Kennedy Space Center. This provided me with the opportunity of working with all of the lunar landing crews, with the lunar hardware, including the Saturn 5 third stage, the Lunar Module, and of course the lunar experiments.

It was a great privilege to work with our American and British Colleagues on such an historic feat of exploration during what has turned out to be a unique period in the history of space flight. For me it was the achievement of a personal lifetime ambition.

Things are much different now, as we are all aware. With the passing of the Cold War, there is no longer the incentive of competing ideologies to drive us forward and the whole of space-related research is suffering major cut-backs in funding, particularly in human space flight. Continued investment now has to be justified. It is no longer sufficient to set isolated goals and expect the taxpayers to provide the money.

So, what is the way forward? A long term space development strategy, with objectives which provide demonstrable benefits for humankind and our planet's environment, is needed. The Space Agencies and industry should also start to exploit proven technology rather than push for the exclusive use of "advanced" technology in new operational space systems. The civil aviation industry has, for many years, successfully used this conservative approach to enhance its operational capabilities. I see some hope, with the continuation of the Delta Clipper programme, that this approach is now gaining support in space developments.

With the establishment and implementation of a long term space exploration and exploitation strategy, I can envisage space flight enabling a progression from a world economy to a Solar System economy by the end of the next century bringing economic and humanitarian benefits for all who take part.

Capt Bob Freitag presents a plaque to Len Carter, which is an exact replica of the one left by Apollo 11 on the Moon. The plaque was given to guests at the 'President's Dinner Honoring Apollo 11 astronauts' on 13 August 1969. It reads:

HERE MEN FROM THE PLANET EARTH
FIRST SET FOOT UPON THE MOON
JULY 1969 A.D.
WE CAME IN PEACE FOR ALL MANKIND

***Donald H. Howie, FBIS** writes:*

I was recruited in England by RCA (Radio Corporation of America) for spacecraft work in their New Jersey Astro-Electronics Division where I worked from April 1964 to September 1970.

My first involvement was in thermal-vacuum testing of the solar arrays, antennas and a thermal model of a lunar orbiter, a key project within the overall Apollo Program.

Later I designed a test rig for simulating the intense thermal flux that played on the back of the lunar module upper-stage rendezvous radar antenna when particular attitude control thrusters were fired.

I also worked on the thermal-vacuum testing of the automatic deployment of the 10 ft diameter erectable antenna, deployed at the Moon to transmit TV pictures back to Earth.

***John L. Gedge, FBIS** writes:*

Between 1966 and 1969 I was at the Bendix Aerospace Systems Division in Michigan. Bendix were Prime Contractors of the Apollo Lunar Surface Experiments Package (ALSEP), a series of scientific experiments connected to a central telecommunications station and deployed on the Moon by the astronauts where it operated for a year.

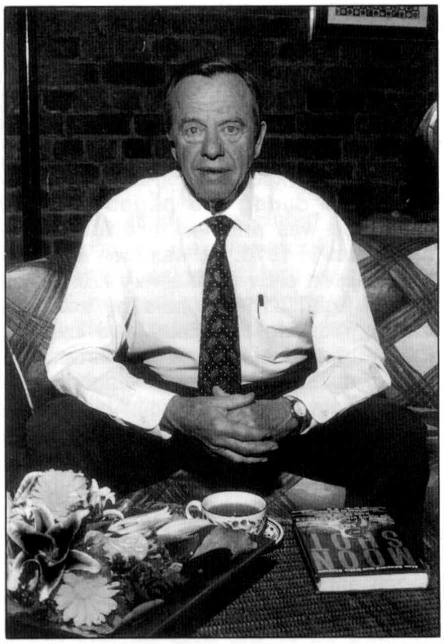
I was Project Engineer, totally responsible for the Dust Detector Experiment. Also, I designed the electronics of the Active Seismic Mortar Box and managed the Geophone subcontract and system testing of the whole experiment.

In Remembrance of Things Past

Looking from the Present to the Future

To coincide with the 25th anniversary of the first Moon landing, two new 'space' books have been published. The first of these books, *Moon Shot*, has been written by Alan Shepard and Deke Slayton and gives a first-hand account of the space race as seen by these two pioneering astronauts. The second book, *Exploring Space*, by BIS Fellow David Shayler has a foreword by ex-Shuttle astronaut Joe Allen and is aimed at a younger audience.

Mindful of the inevitable media interest in the 25th celebrations, the two publishers each brought over an astronaut to help publicise the books. Therefore, during the last two weeks of June, the UK played host to two astronauts - Alan Shepard and Joe Allen - and *Spaceflight* interviewed them both.



Alan Shepard at Granada TV studios in Liverpool's Albert Dock on 28 June during his visit to promote the book *Moon Shot*.
RICK MULHEIRN

BY IAN A. MOULE
Northants, UK

I began the interview with Alan Shepard by asking him about the genesis of his book:

It was Deke Slayton who was originally approached about writing a book. However, he fell ill and was subsequently diagnosed as having cancer. Shepard was then asked to help his old friend out and, due to the nature of the request, he "couldn't refuse". Also, Shepard felt that Slayton's story should be told as the astronaut was highly regarded. Unfortunately Deke died before the book was published, but he did live long enough to see the first two drafts. Although very pleased with the initial sales, Alan has stated, "this will be my only book!"

We then went on to discuss his historic flight in Freedom 7:

Alan takes great personal pride in being the first American in space and was very pleased with his five minutes of weightlessness. The fact that he was not the first man in space is tempered by the fact that during his flight he became the first person to manually control a spacecraft. This proved that in the same way as a pilot controls an aircraft, "a pilot could fly a cone!" He then went on to point out that Yuri Gagarin and the other early cosmonauts were only 'passengers' in an automatically controlled spacecraft. Alan had tried to convince Wernher von Braun that the next flight after Ham's (the chimpanzee) should be manned. Unfortunately he was not successful since it was decided that a further unmanned test was needed. Alan ended by saying that the Mercury capsule was more technically advanced than its Soviet counterpart.

Moving on to Project Apollo, Alan had the following comments to make regarding President Kennedy's challenge:

Alan's flight in Freedom 7 aroused a genuine enthusiasm for space exploration in President Kennedy and this interest became apparent to Shepard during his medal ceremony at the White House. After presenting Alan with the NASA Distinguished Service Medal, Kennedy, on the spur of the moment, convened a special meeting with NASA and Congress officials to discuss the future direction of America's manned space programme. Shortly after this meeting President Kennedy set NASA the goal of a manned lunar landing within the decade; a timescale which some people felt was too short.

Kennedy's challenge was backed up by good leadership and this enabled rapid developments in engineering to be made. This meant that in January 1971, nearly 10 years after his sub-orbital space flight, Alan, as Commander of Apollo 14, was in a position to fly to the Moon. The rocket that would send him on his way was the giant Saturn V, which as his book describes, "was nearly 5 times taller than his old Redstone, 100 times more powerful and even had escape rockets which were twice as powerful as his Redstone booster".

I then asked Alan about a couple of the activities on the Moon which were unique to Apollo 14:

Apollo 14 saw the first and only use of the Modularized Equipment Transporter (MET), a hand-cart, which was the only Moon vehicle to use pneumatic tyres. Alan recalls that the MET handled "OK" on the flat lunar surface, but its high centre-of-gravity made it unstable on rough, rock-strewn ground. Also, the act of pulling the MET across the surface meant that both he and Ed Mitchell had to use a more Earth-like walking motion, rather than the moonwalkers' usual 'lope'. He then went on to remark that as he and Mitchell climbed up the side of Cone Crater the dust became so thick that they "picked up the MET and carried it!"

For all his activities on the lunar surface, Alan is probably best remembered as being the first person to play golf on the Moon. As he said, "It was a fun thing, and I knew that the ball would go 6 times as far!" The 'club' itself comprised of a 6-iron golf-head which had been designed by Alan so that it would snap on to the end of the telescopic contingency sample return handle. On returning to Earth, Alan gave the 'club' to a golfing museum where it is now on display.

Finally, I asked Alan what his lasting memories were:

Although Alan has various memories of his flight and walk on the Moon, he does not have one specific memory. Depending upon how he feels, coupled with the events of everyday life, any one of his memories may be upper most in his mind. However, his Frau Mauro landing site is "visible on a clear night" and he sometimes uses binoculars to examine the region he once visited. He occasionally sees the other members of his crew, Ed Mitchell and Stu Roosa, and they may get together to celebrate the 25th anniversary of Apollo 14, but nothing is planned. With regard to the soil and rock samples he brought back, Alan has no sentimental attachment to them and does not feel strongly about wanting a small piece of Moon rock. A point he underlines by restating the fact that he has donated his 'golf club' to a museum.

Interestingly, Joe Allen's story begins where Alan's left off because Joe was CapCom on Apollo 15. I caught up with Joe at the Science Museum in London, where he and David Shayler were preparing to give a talk entitled "At Home in Space". I began the interview by asking Joe about his early days at NASA and his involvement in Project Apollo:

Joe applied to become an astronaut "out of curiosity" after responding, in 1966, to a NASA notice which had been pinned on a bulletin board at Yale University. He was selected in August 1967. One of the members of his 11 strong, sixth astronaut intake, was a Welshman named Tony Llewellyn. Joe recalls that Tony, who could have been the first 'Brit' into space, was "quite a nice guy" and that they were "quite good friends". After Tony left the programme the two of them kept in touch for a number of years.

Although Joe would have liked to have gone to the Moon, he never made it. As he said, "It was never very clear during my time at NASA that I would get the chance to go and NASA certainly didn't promise it!" However, Joe was lucky enough to work on a Moon flight and he greatly enjoyed "the fun, the excitement and the challenge of working on a remarkable undertaking". He loved being the Capsule Communicator (CapCom) on Apollo 15

and after that mission ended he served as CapCom on the last ever Moon flight, Apollo 17.

I then asked Joe about the long years between the end of Apollo and his first flight on the Space Shuttle.

Having worked on non-astronaut assignments during the period 1974 to 1978, Joe was returned to official astronaut status in 1978. He was then assigned as a support crew for the very first Space Shuttle flight, STS-1, where he acted as CapCom during the Entry and Landing Phase of the mission. This part of the STS-1 mission was "surprisingly easy" since all the procedures unfolded exactly as they had planned them. Therefore very little communication was required between Mission Control and the Shuttle. In fact Joe recalls that it was nearly "a letter-perfect flight!" After writing his part of the STS-1 "End of Mission Reports", Joe began immediate preparations for his own flight, STS-5.

Moving on to his first Shuttle flight:

Although STS-5 was officially declared to be the first operational Space Shuttle flight, Joe and the rest of the crew still regarded the mission as a test flight, "just as the other four had been". To them the word 'operational' was "only in the minds of the politicians!" However, Joe did become the first passenger to go into space because he did not have any specific flight assignments to perform during the ascent.

I then asked Joe what he thought was the most dramatic part of a Shuttle mission:

For Joe there are many dramatic parts to a space mission; the launch, the endless floating in Earth orbit, and the rather gentle, "but attention-getting" glide back to Earth. Each one is "unique" and each one is "spectacular", and he would be hard pressed to "put one in front of another!"

Finally, I asked Joe about his second, and last mission, STS-51A when he used the Manned Manoeuvring Unit (MMU) to salvage the 'lost' Palapa satellite:

Joe found the MMU "very easy to use" and it worked just like the simulations on the ground had predicted. The main constraint placed upon him was the fact that he had to get to the satellite and capture it before the 45 minutes of daylight ended. They did not want to be "out trying to chase satellites down" when they had gone behind the limb of the Earth. In the event, Joe had plenty of time. He described the capture of Palapa by the insertion of the 'Stinger' into the open end of the spent rocket engine nozzle as "just like threading a rather fat needle into a not all that large hole!" He did have one problem and that was judging distances; "in space you don't tell distances very well".

After bringing Palapa back to the Shuttle, Joe was then tasked with having to manoeuvre it manually. Although the satellite was weightless, it was not massless and Joe had to contend with over 1,000 lb of inertia. As he put it, "you don't get started in a motion that you later cannot deal with!" At the end of the EVA he was understandably "physically tired".

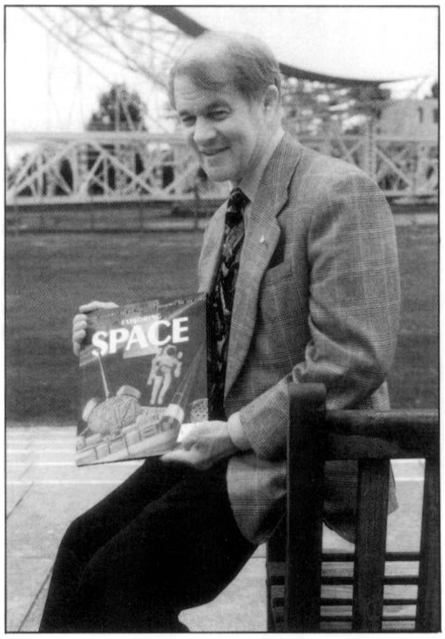
What of the Future?

Alan Shepard has no predictions due to the current budget restraints in the US, Japan, Canada and Europe. However he did refer to a Soviet launch in 1997 of the first parts of the Space Station which is due to be permanently inhabited in 2002. He also feels that space technology, such as the Space Station, would be a very good means of monitoring the ecological state of the Earth's environment and this technology could then be used to draw attention to the issues of ozone depletion, urban pollution, etc. Although concerned about the health of the Earth's environment, Alan does have a "problem with some environmental issues". "Even if they are not basically political, they are very narrow, concentrating on specific issues".

Regarding lunar exploration, Alan thinks that further unmanned probes are possibly required to explore the far-side of the Moon and that manned missions to the Moon would need "an over-riding requirement" such as the mining operations for helium-3 for use in clean fusion reactors. This may happen one day but he feels that it is unlikely that any generation will ever repeat the Apollo Program. He ended by saying that in the US, "future space activities will depend on favourably impressing their need to Congress".

Joe Allen has no specific predictions. When Joe was CapCom on Apollo 17 he and the rest of the people at NASA knew that it was going to be the last trip to the Moon for awhile. However he somehow pictured, 25 years ago, that there would be a hiatus but with a commitment to return "this time to stay and then on to Mars!" In fact Joe points out that this commitment was actually made by an American President on the 20th anniversary of the Moon landing. Unfortunately, President Bush did not have the Congress behind him when he made the commitment so it has basically been ignored. Joe now feels that because of the lethargy in elements of the space programme the US is now "more years away from the Moon than history shows it was in 1961 when Kennedy said let's go before the end of the decade!"

On a more optimistic note, Joe thinks that the Biosphere II experiment was very interesting and "bold in the extreme!" He points out the Biosphere people did it "with the money they raised themselves" and that "they did not depend on the US government to do it!" Also, they were able to do something and an "enormous amount was learnt".



Joe Allen at Jodrell Bank on 23 June to promote Davy Shayler's book *Exploring Space*. RICK MULHEIRN

The 11 members of the sixth astronaut intake. Joe Allen is standing on the extreme left. Dr John A. 'Tony' Llewellyn is seated on the extreme right. NASA

Acknowledgements

I would like to thank the following people who made this article possible. Alan Shepard and Joe Allen for the giving of their time to answer my questions; Susan Atkinson of Midas Public Relations and Alison Gilbert of Reed Children's Books for arranging the interviews; and my work colleague, David Bull for his invaluable assistance during the Alan Shepard interview.

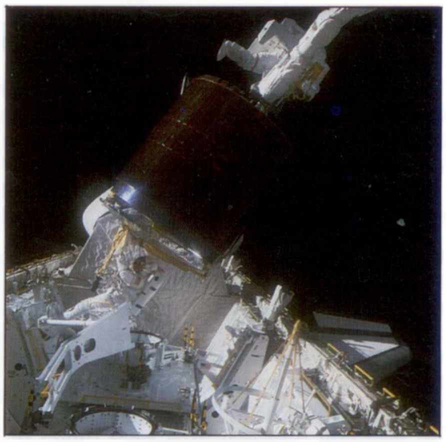
Astronauts at Jodrell Bank

Sir, On separate visits, two Space Shuttle astronauts (ESA's Claude Nicollier and NASA's Joe Allen) visited the Jodrell Bank Radio Telescope in Cheshire. Both astronauts gave illustrated talks of their experiences as astronauts.

On 22 June, Claude Nicollier gave an excellent presentation on his involvement with the Hubble Telescope repair mission showing vivid slides of his mission and some of the results obtained with the repaired Hubble Telescope. During a question/answer session he noted that the pre-mission view of success with the Hubble Telescope repair mission was rated at only 20%! He said that there were over 300 tools aboard for the repair mission and that he had spent many weeks of 30-hours/week in preflight simulations. Before and during the launch of the Space Shuttle he said that he had a mixture of 'joy' and 'fear' about the liftoff. He said that during the ascent of the Space Shuttle he could feel the shaking and vibration noise in the cockpit.

On the following day, 23 June, ex-NASA astronaut Joe Allen gave an illustrated talk of his experiences aboard the Space Shuttle. One set of comments concerned his involvement on the Palapa satellite mission. He was one of the EVA astronauts and as he was 'riding' the robot arm on the Space Shuttle, he had "a feeling of vertigo" but it reminded him, as he viewed the Indian Ocean below, that he was probably on the world's highest diving board.

PHIL PARKER, FBIS
Staffordshire, UK



STS-51A: Joe Allen using the MMU after returning with the Palapa satellite to the Shuttle and attaching it to the RMS arm. The other astronaut in the photo is Dale Gardner. NASA

Astronaut Joe Allen

Ben Evans with Joe Allen.

Sir, At Stourbridge Town Hall in the West Midlands on 23 June, I was privileged to meet astronaut Joe Allen, who flew on the STS-5 and STS 51-A Shuttle missions in November 1982 and November 1984 respectively. He spoke at length to a large audience about his experiences of space travel.

After the talk, members of the Midlands Spaceflight Society returned with Mr Allen to his hotel, where he answered our many questions and also discussed the Shuttle re-entry sequence in meticulous and fascinating detail. He called the Shuttle "an engineering marvel and an economic disaster", and when I asked him about the advances made in EVA training techniques during the last decade, he replied that the STS-61 (Hubble) crew trained in exactly the same fashion as his STS 51-A (Palapa/Westar) crew. He expressed no criticism of the withdrawal of the Manned Manoeuvring Unit (MMU) "jet backpack" from service some two years ago. He believed that the space programme's future should be put in the hands of scientists and engineers rather than politicians.

BEN EVANS
West Midlands, UK

Spacecraft Model Photography

Sir, In my article on model photography that appeared in the September 1993 issue of ***Spaceflight*** I mentioned that when double exposing two elements on to the frame it is impossible to superimpose the model on to the Earth without a resultant "ghost" image.

Since then I have scratch built a 1/72 model of the Hubble Space Telescope together with a Revell space shuttle model as shown on the right. Quite by accident, a model partially obscured the previously exposed Earth without a ghosting effect. This occurred as a result of the model being white and the dark blue of the Earth being obliterated by the brightness. I therefore decided to experiment and see how much you could get away with, hence the photo below of the HST over the Earth.

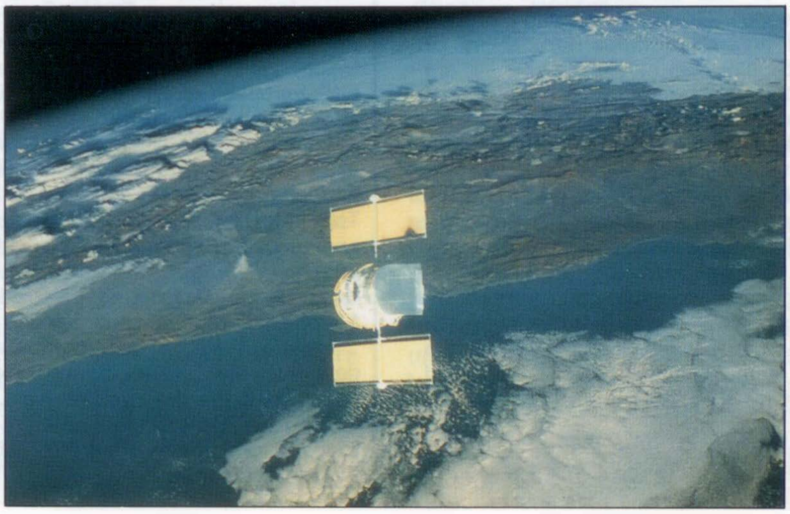
I have discovered that if you carefully choose a slide with dark colours, preferably blue or brown and pick a model which is either white or in the case of Hubble, highly reflective, the brighter object will superimpose itself without a noticeable ghost effect. However care has to be taken that no part of the model casts a shadow on the rest of the model as the previous exposure will show through.

I hope that the above will help any budding model spacecraft photographers produce even more realistic results.

KEITH A. McNEILL, FBIS
Edinburgh, UK

Endeavour with HST berthed.
© KEITH A. McNEILL 1994

HST above the Earth. © KEITH A. McNEILL 1994



In Praise of ISU

The International Space University holds an annual 10-week summer session to teach all aspects of space exploration and development at graduate level. A detailed account of the intensive programme of study and project work at the 1993 session at Huntsville appeared in the April issue of *Spaceflight*.

***Jason P. Hatton*, who was a member of the 1993 British delegation, now provides a personal account of the influence that ISU had on his career.**

It was in June 1993 that I stepped off an aircraft at Huntsville International Airport and started work at the International Space University 1993 summer session. What happened in the intervening time has had a very profound effect on my life. Now I am involved in 'cutting edge' space life sciences research in a wide range of orbital missions, something that I thought would take years to achieve. The key event that has made all of this possible was attending ISU.

ISU concluded on 27 August in a closing ceremony addressed by Arthur C. Clarke, the University's Chancellor, via video phone from Sri Lanka. As I looked back on the preceding weeks I realised I was a very different person from the one who had arrived at Huntsville airport two and a half months earlier. Then I had felt unsure whether my own abilities were up to the standard required and, although I certainly knew a lot about space flight, I had had little direct experience of real space hardware. In the meantime I had become fully confident of my own abilities and I was sure that I was capable of achieving anything that I set my mind to.

During the summer session I was exposed to a wide range of disciplines spanning the entire range of space related topics. This served to broaden my knowledge of all space related activities, which is useful for any space career, since most space ventures require multi-disciplinary knowledge. ISU is truly international and 100 students representing 28 different nations attended the 1993 summer session.

Throughout ISU I had to work very closely with these people to achieve a common goal, the completion of a credible, detailed design project before the closing ceremony of the session. From this I gained a unique understanding of many different cultures and how to work effectively in a multi-national/multi-disciplinary group. This was invaluable experience that will help me to work in "real world" situations involving groups with a diverse composition. Many of these people, both students and staff, are those that I am likely to work with again in the future and it is wonderful that we all have the common bond of ISU.

This was not only my first trip abroad, but also the first time I had really had the opportunity to see space hardware "for real". The numerous opportunities to see Space Shuttle hardware, often in "action", greatly enhanced my appreciation of this system in a way that cannot be obtained by any other means. Indeed the whole of the summer session was filled with many new and interesting experiences.

Learning about such a wide range of topics helped me to assess which area of the space life sciences I wanted to make my career in. By the end of the summer session I had made the decision to try to find my ideal career opportunity; something involving a lot of space experimentation in a research field very central to space medicine. ISU had strongly bolstered my confidence and belief in my own abilities and I knew that if I tried hard enough I could get the correct research position for me, which would set my career back on course. Neither the search for nor starting a new research position would be easy, since it would invariably involve leaving Britain, but if this venture paid off it would be worth the effort.

On my return from ISU things started to move rapidly, mainly because two major space life science conferences took place in the weeks following ISU. I was already booked to attend the "5th European Symposium on Life Sciences Research in Space", in Archachon, France, an ESA sponsored conference at the end of September, which would give me an opportunity to meet European researchers. Meanwhile I decided to pay for my own attendance at the annual American Society for Gravitational and Space Biology conference at Washington DC during mid-October, so that I could meet the US research groups. To further improve my chances of obtaining a research position I wrote to a number of research groups that I was interested in working with, enquiring about possible opportunities. I soon had a number of replies and soon realised that it was not simply a case of finding an opportunity, but which opportunity to accept! By the time of the Washington conference I had nearly a dozen good offers of research positions.

Finally I settled for a position with one of Europe's leading laboratories to study the effects of space flight on the immune system, run by Dr Didier Schmitt an Alumni of ISU '89. Here I am preparing several experiments for orbital space flight, research which will contribute to my PhD with Université Louis Pasteur. The laboratory is situated in Strasbourg, France which is also the location of the new ISU Central Campus. Therefore not only am I now able to work at the "cutting edge" of space life sciences research, but have a unique opportunity to contribute to the continued success of ISU by assisting in the teaching of the permanent campus programme.

Acknowledgements

I greatly appreciate the financial support provided by the organisations that sponsored my attendance at ISU '93, without which I would not be in my current situation. Therefore an especial 'thank you' goes to the Rocket Publishing Company and to the European Space Agency for financing my attendance at ISU. Additionally I would like to thank Mrs Sue Bayford for her considerable efforts on behalf of the Space Education Trust effort to secure funding for the British students who attended in 1993.

JASON P. HATTON

ESA Parabolic Flight Competition

The results have been announced of the ESA competition which invited students to submit proposals for experiments to be carried out under microgravity conditions on board an aircraft in parabolic flight. Not less than 49 entries were received from all over Europe.

The Selection Jury, under the chairmanship of ESA astronaut Wubbo Ockels, selected those experiments best adapted to be flown on the special flight, organised by ESA with the support of the Society of Space Engineering Students of the Delft University of Technology (the Netherlands) and of the European Union, within the framework of the Second European Week for Scientific Culture in November 1994.

Among those selected were two UK entries, one from the University of Kent and one from Ashford School in Kent. The latter came from Alison Hickman and Eleanor Fell and was entitled 'Spiral crystalline growth in chemical gardens'. Experiments were selected from 11 other European countries.

Hajime Yano, a post-graduate student from the Unit for Space Sciences, put forward the proposal for the University of Kent. He explained "We are going to test a device called the Fluid Coil Activator, designed to orientate freely floating astronauts. It is basically a coil of water-carrying tubes that wrap round the body. The water rotates one way and this forces the astronaut to rotate the other due to the conservation of angular momentum. Currently they use backpack thrusters for self-manoeuvring outside a space shuttle but these are expensive, produce debris and can be dangerous. Our device is light, economical and safe and it can be implemented in a space suit. We obviously need to test it in microgravity conditions and the Caravelle flight will be the ideal opportunity".

Hajime and Wayne Brook-Thomas, another post-graduate in Space Sciences, will be free-floating in the cabin of the Caravelle during short periods of weightlessness which create the conditions experienced by astronauts in space. The flight is very arduous so both Hajime and Wayne will have to pass a medical aeronautical examination before flying.

A video will be made of the students' work on board the Caravelle which they will use in their research work. The University will also make the video available to schools and sixth-form colleges, together with an accompanying information pack, for use as part of 'A' level Physics project work.

About the Mir Station

The Mir space station circles the Earth at an altitude of between 350 and 400 km in an orbit with an inclination of 51.6°. In its present configuration, Mir consists of four main modules: the Mir core module and the scientific modules known as 'Kvant', 'Kvant-2' and 'Kristall'.

The Mir core module, which was launched in February 1986, has a mass of approximately 21 tons, a length of about 13.1 m and a maximum diameter of 4.2 m. It consists primarily of a passage area with five docking ports, a working area housing the command station, living/eating and hygiene facilities, and a propulsion section through which a tunnel allows access to the Kvant module.

Kvant, an astrophysics module that accommodates instruments from several countries was docked to the Mir core module in April 1987. It is about 5.8 m long, has a maximum diameter of 4.15 m and a core mass of about 11 tons.

Kvant-2, a module housing scientific and technological experiment equipment, a shower facility and an airlock supporting extra-vehicular activities (EVA) by the crew, was docked to the station in December 1989. It has a mass of about 19.5 tons, a length of 11.9 m, and a maximum diameter of 4.35 m.

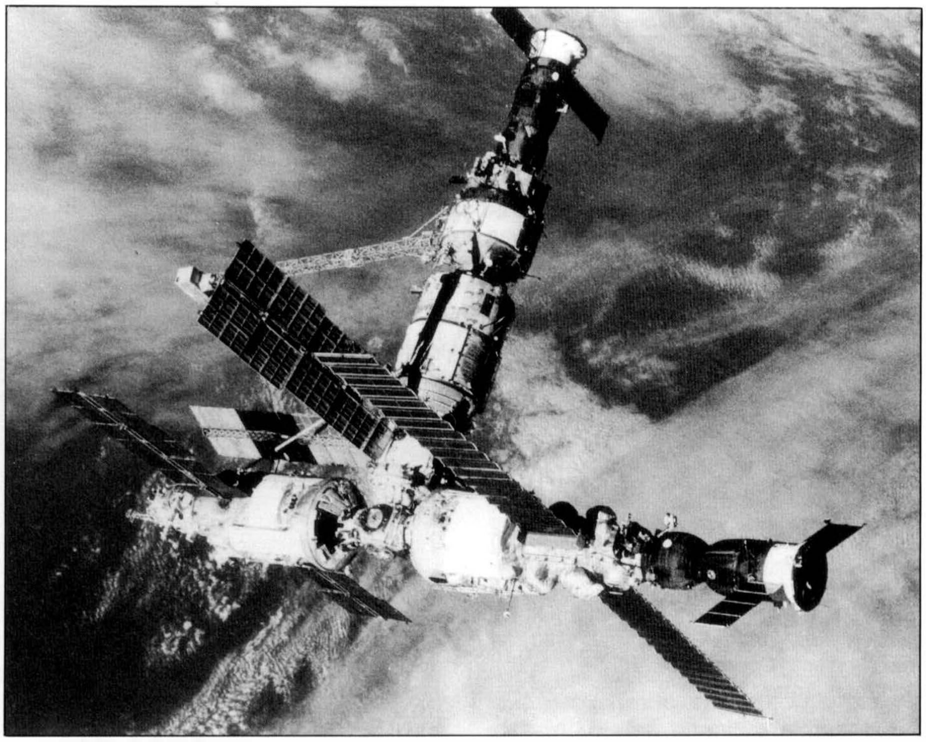
The Kristall module joined the station in June 1990. It is mainly dedicated to technological research, such as semiconductor and biological experiments. It also houses Earth-observation instruments. The mass and dimensions of Kristall are similar to those of Kvant-2.

In August 1992, a thruster package, known as 'Sofora', was installed on a 14 m mast mounted on top of the Kvant module. These thrusters allow efficient and propellant-saving attitude control of the station.

Two further modules are planned to be added to Mir. The 'Priroda' module, mainly dedicated to Earth-observation tasks such as ocean surface-temperature measurement and studies of ocean/atmosphere interactions, and the 'Spectr' module, supporting studies of the Earth's atmosphere.

Logistical resupply of Mir is provided by the unmanned Progress system, with a payload capacity in the order of 2.5 tons. The crew is transported to and from the station with the Soyuz-TM vehicle, which can accommodate three astronauts/cosmonauts per trip. Both the Soyuz-TM and Progress are expendable systems and are launched by the Soyuz launch vehicle.

The results of the experiments, including samples, film, etc, are usually returned to Earth by the astronaut/cosmonaut on-board the Soyuz-TM capsule. A special unmanned re-entry capsule enhances these return capabilities.



The Mir orbital station. PHOTO NPO ENERGIYA FOR ESA, AUGUST 1993

(An annotated diagram of Mir may be found in the February 1994 issue, p.50).

ESA Astronauts for Mir

Two planned missions to Mir by ESA astronauts in October 1994 and August 1995 will represent an important step in the intensification of cooperation between ESA and the Russian Federation in the field of manned space flight. They will not only benefit the European user community by providing long-duration experiment possibilities, but will also offer flight opportunities to ESA astronauts in the near term, thus helping to prepare Europe for the exploitation of a future manned space infrastructure in an international context.

The cooperative programme provides for two Mir missions in the 1994-96 time frame, called EUROMIR 94 and EUROMIR 95. The EUROMIR 94 mission is planned to be launched on 3 October 1994 and will have a duration of about 30 days. The activities of the European astronaut will be concentrated mainly on conducting physiological and some materials experiments. The EUROMIR 95 mission, to be launched on 17 August 1995, will last up to 135 days. On this trip, the European astronaut will not only perform experiments, but will also be trained and qualified as a flight engineer, with defined responsibilities for Mir station operations. During this mission the ESA astronaut will also undertake EVA sorties outside the station.

The flights will follow the typical sequence of key activities described below:

- Launch of an unmanned Progress vehicle, accommodating most of the ESA payload, to the Mir station approximately one to two months prior to the launch of the ESA astronaut;
- Launch of the European astronaut and two cosmonauts, together with the remainder of the ESA payload, with the Soyuz-TM;
- Rendezvous and docking of the Soyuz-TM with Mir about two days after launch;
- Station hand-over activities from the outgoing crew to the newly arrived crew, including the ESA astronaut (nominal duration about one week for EUROMIR 95; extended duration of about one month for EUROMIR 94), and start of the experimental programme;
- Return to Earth of the outgoing crew (for EUROMIR 94, together with the ESA astronaut and the ESA experiment results) with the Soyuz-TM;
- For EUROMIR 95, continuation of the experimental and operational programme by the ESA astronaut and the cosmonauts;
- Return to Earth of the ESA astronaut, the two cosmonauts and the ESA experiment results by Soyuz-TM, after hand-over of the station to the new crew.

The ESA astronaut on each mission will perform experiments in the space-science, material-science, life-science, fluid-science, and basic physics and technology domains. The Earth-observation opportunities offered by the high inclination of the station's orbit will also be considered.

ESA Astronauts for Mir

Crew Personal Details

Ulf Merbold was born in Greiz, Germany on 20 June 1941. After finishing University, he joined the Max-Planck-Institute for Metals Research in Stuttgart, his main fields being solid state and low temperature physics.

As the first non-American, he participated in Shuttle mission STS-9 in 1983 and, in 1984, he was involved in the D-1 mission, in a dual role, as back-up Payload Specialist and as Crew Interface Coordinator.

In 1986, he was transferred to ESTEC in order to support ESA in the planning of Columbus, the European contribution to the International Space Station "Freedom".

In 1992, he flew as an ESA astronaut on the IML-1 mission (STS-42) being primarily responsible for the 55 scientific experiments on the flight. During the German D2 mission from 26 April to 6 May 1993, he was Science Coordinator at the Mission Control Center.

Pedro Duque was born in Madrid, Spain on 14 March 1963. He graduated from Escuela Técnica Superior de Ingenieros Aeronáuticos, Universidad Politécnica, Madrid in 1986 and at the end of 1986 worked within the Precise Orbit Determination Group at ESOC until 1992. He was also part of the Flight Control Team of the ERS-1 and Eureca satellites.

In May 1992, he was selected as an ESA Astronaut Candidate and later that year completed the Introductory Training Programme at EAC and a four week training programme at Star City with a view to future ESA-Russian collaboration in the Mir Space Station.

Christer Fuglesang was born in Stockholm, Sweden on 18 March 1957. As a graduate student Fuglesang studied proton-antiproton collisions at CERN and a year later he became Senior Fellow there.

In May 1992, he was selected as an ESA Astronaut Candidate and later that year completed the Introductory Training programme at EAC and a four week training programme at Star City with a view to future ESA-Russian collaboration in the Mir Space Station.

Thomas Reiter was born in Frankfurt/Main, Germany on 23 May 1958. He graduated from the Empire Test Pilots School (ETPS) at Boscombe Down, England and in 1992 attended the class 1 test pilot training at ETPS. His flight experience includes 1500 hours in military combat jet aircraft of more than 15 different types.

He has also been involved in the European space vehicle Hermes development activities, and in a parabolic flight campaign for assessment of seats and various Columbus space station equipment.

In May 1992, he was selected as an ESA Astronaut Candidate, joining the European Astronauts Centre in January 1993.

From left to right: astronauts Thomas Reiter, Ulf Merbold, Pedro Duque and Christer Fuglesang training at Star City (near Moscow). ESA

Pedro Duque and Ulf Merbold have been training for EUROMIR 94 (30 days in orbit). Christer Fuglesang and Thomas Reiter are training for EUROMIR 95 (135 days in orbit). Ulf Merbold has now been selected for the EUROMIR 94 mission.

Astronaut Training

In August 1993, the four ESA astronauts began training at the Yuri Gagarin Cosmonaut Training Centre near Moscow, known as 'Star City'. For each mission, there will be one nominal astronaut and one back-up, both of whom will follow the same training programme.

The astronaut followed ESA basic training and intensive Russian language courses at the European Astronauts Centre (EAC) near Cologne, Germany, to prepare themselves both for the training sessions at Star City and the subsequent on-board mission operations, which are all conducted in Russian. A one-month stay at Star City in November 1992 allowed them to familiarise themselves a little with the facilities and the environment of the training centre.

The training in Russia consisted of two major elements: common 'Basic Training' and specific 'Mission Training' for EUROMIR 94 and EUROMIR 95, respectively. The common Basic Training lasted about four months and included such topics as the theory of manned space vehicles, manned space vehicle control systems, fundamentals of space navigation, Soyuz-TM systems, an overview of the scientific experiments and research conducted on Mir, general EVA training and biomedical training, as well as lessons to maintain proficiency in the Russian language.

The subsequent Mission Training included technical training, biomedical training, Russian language proficiency maintenance and crew training in the Soyuz-TM and Mir simulators. The Mission Training for EUROMIR 95 will feature significantly enhanced training time on Mir systems and operations, and special EVA training sessions, mainly in the neutral-buoyancy facility at Star City. The Mir-95 post-mission activities are expected to be completed in early 1996.

Crew Selection

On 30 May 1994, during a press conference at the ILA '94 Berlin Airshow the selection of Ulf Merbold as a member of the crew scheduled to fly for the EUROMIR 94 mission in October was announced.

With ESA astronaut Ulf Merbold, the Russian cosmonauts for this EUROMIR 94 mission are Mr Aleksandr Viktorenko, Commander (who will be thus doing his fourth flight on-board the Mir station) and Mrs Elena Kondakova, Engineer. The second crew, which was trained in parallel and ready to fly in case of problems with a member of the first one, is composed of ESA astronaut Pedro Duque and cosmonauts J. Gidsenko and S. Avdeyev.

About three weeks before the launch, the flight readiness of both crews will be assessed and prime and back-up crews nominated.

The ESA astronaut on-board the Mir station will act as Research Cosmonaut, being fully responsible for the experimental programme and for selected tasks to be performed on some systems of Soyuz and Mir. He will be involved in the final mission preparation, mission execution and post mission activities. The back-up ESA astronaut will also have an active role in the experimental programme by insuring communication flow and experimental performance as Crew Interface Coordinator at the Mission Control Centre in Kaliningrad, Russia.

Limitations on ESA Payloads

The choice of experiments to be performed on Mir for the 1994 mission is restricted by a 16 kg limit on the weight of payload that may be brought back by the Soyuz capsule.

The return of products from time-critical experiments is therefore a major problem and priorities have been given to which products to bring back. In the event, it is the biological blood, urine and saliva samples that will return to Earth with the European astronaut on Soyuz and even then there will be fewer urine samples than was originally planned !

A payload of 150kg of European equipment will be taken up to Mir by the Progress ferry craft for the EUROMIR 94 mission. Some 350kg of European equipment will be installed for the second mission. However, the Shuttle will visit Mir up to ten times over the period 1995 to 1997, foreshadowing the development of the International Space Station, and since EUROMIR 95 is to take place during this time it may be possible to use Shuttle flights to carry equipment up to Mir and return samples to Earth.

Preparation Flights for International Space Station

Crew changes are planned every three to six months for the International Space Station and the EUROMIR flights are considered as precursors for European participation in this work as well as being an excellent opportunity to perform scientific experiments and prepare the user community for the forthcoming era.

On EUROMIR 94 the astronaut will work for up to 12 hours a day of which six hours will be dedicated to scientific work. Saturdays and Sundays will be rest days. This means that 100 or so hours will be spent on the mission's scientific programme. By extension, this will go up to about 450 hours for EUROMIR 95 of 135 days duration.■

Based on an edited version of the ESA publication 'Cooperation with Russia in the Framework of the Columbus Precursor Flights' by W. Nellessen and H. Arend and other information supplied by ESA with assistance provided by J.K. Andersen, Denmark.

BIS Welcomes ESA Astronaut
Claude Nicollier

"I believe that manned space flight responds to needs deeply rooted in human nature: research, adventure, exploration of the last frontier, which is forever being pushed back by the conception and development of new technical resources. My great hope is that Europe will join forces with the United States and Russia on programmes to return to the Moon and explore Mars". - **Claude Nicollier**

The British Interplanetary Society is pleased to announce that ESA Astronaut Claude Nicollier will address the Society at a special meeting in Central London on 24 September 1994.

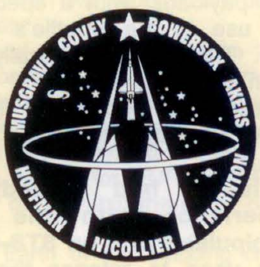
Claude, who is a Fellow of the Society, was the first European Mission Specialist astronaut. He was involved in the release of the Eureca satellite during mission STS-46 in 1992 and in the repair of the Hubble Space Telescope during mission STS-61 in December 1993. Claude's role in both Shuttle flights has been the operation of the Remote Manipulator System (RMS) arm and reflects his interest in the developing importance of the man-machine interface in astronautics.

Claude Nicollier. NASA

Claude Nicollier is an excellent and enthusiastic speaker and his visit to London promises to be an event that is not to be missed by anyone interested in current and future developments in astronautics.

Earlier this year he visited British Aerospace, Filton with the other STS-61 astronauts and spoke to *Mark Hempsell*, who writes about the interview overleaf. *Mark* says, "I recommend every BIS member to make every effort to rendezvous with Claude on 24 September and to hear what he has to say. Meeting him is a real treat".

Hubble Repair Mission Astronaut
Claude Nicollier



at

The Scientific Societies Lecture Theatre,
Fortress House, New Burlington Place,
London W1

at 4 pm on

Saturday, 24 September 1994

ESA Astronaut and BIS Fellow Claude Nicollier will talk about his work and the Hubble Repair Mission of December 1993.

Members are cordially invited to attend. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

Meeting ESA Astronaut Claude Nicollier

On 14 February, British Aerospace at Filton hosted a visit from the astronauts of the Hubble servicing mission STS-61. *Spaceflight* took the opportunity of an exclusive interview with ESA astronaut Claude Nicollier who flew as a mission specialist. Claude summed up the importance of the STS-61 flight to the scientific community.

"I am extremely pleased with the results of this mission and what it means for the scientific community and for all astronomers of the world. We now have an instrument that means a quantum jump in our ability to see and observe the Universe. It is the same quantum jump as we had when Galileo used his telescope. With the telescope of Galileo we went from about 1 arc minutes (the resolution of the naked eye) to a few arc seconds - a factor of 10 improvement - and here with Hubble we have another factor of 10. So expect a revolution in our knowledge of astronomy pretty similar to the one we had when Galileo pointed his telescope to the moons of Jupiter, and the crescent of Venus and other objects in the universe. This is amazing, it is fantastic, it is a new wave of knowledge that will come in astronomy."

NASA was not obliged to take an ESA astronaut apart from obvious diplomacy. However Claude's experience and background made him an obvious choice for the mission. He is the only non-American to be flown as a mission specialist (the crew members who operate instruments and payloads) with a specialisation in the use of the Shuttle's manipulator arm. The mission critically depended upon the arm, to recover the Hubble telescope, to support all the servicing EVA's, and then to deploy the satellite again.

Claude had already gained experience with the Shuttle's manipulator arm on STS-46 where it was used to release the European Eureka platform.

"I think my experience with the arm, was quite valuable, It went very well with Eureka."

Like many astronauts Claude is an experienced jet pilot both as an airliner pilot for Swissair and now flying Hawker Hunters for the Swiss Air Force. So how did controlling the arm compare to flying jets?

"In a way it has a lot of similarity with flying an airplane, although the control laws are different. I think the demonstrated ability to be able to cope with fast aeroplanes is certainly a plus when you become an arm operator. It involves a lot of hand eye coordination that you can practice flying aeroplanes".

As Claude is already the first non-American to fly as mission

BY MARK HEMPSELL
University of Bristol

specialist, would his extensive flying experience ever get him into one of the two pilot's seats?

"I don't think NASA will ever let non-US citizens to do that so I don't think there is any chance of doing an ascent or reentry. However I had the opportunity do some manoeuvres with the Orbiter during the on-orbit phase. The mission specialist is the third person to operate the Shuttle and perform manoeuvres and I did a few manoeuvres myself from the forward station with the computer keyboard."

In addition to his qualifications as an astronaut Claude was also an obvious candidate for the Hubble mission as he also has a background as a professional astronomer. He was therefore in a position to understand the significance of Hubble to the scientific community.

His work at the University of Lausanne and at the Geneva Observatory involved photometery and classification of super giant stars. So would Hubble actually aid the sort of work he used to do?

"Hubble probably won't be used for that as the work was done on the basis of relatively nearby stars in our galaxy. Hubble will be used much more for extra-galactic work and looking at far away objects such as quasars. It will be able to see Cepheids much further away than we have been able to with ground-based telescopes, so we will be able to determine the distance scale of the Universe much more accurately. This is one area where we have not been too successful over the last few years and there is a large uncertainty now in the determination of the Hubble constant. I am sure we will nail down this number and hence the age of the universe to a much better degree. Of course there is also the search for planetary companions around nearby stars and not so nearby stars. Its going to be a fascinating time. The next decade in astronomy I think will be significantly affected by Hubble. It is wonderful to be a part of it".

Claude had a final comment on what he felt the mission proved.

"I think it was a culmination of unmanned and manned spaceflight at its best. Hubble is an unmanned spacecraft, but has the capability to be serviced by manned means with all the flexibility that we have using man. This is the best possible use of the Shuttle as a servicing tool. It could not have been done with any other vehicle nor with only robotic means. We did not have many glitches but we had a few - such as a door that doesn't close - robots would not be able to handle that. I think it was a good demonstration that manned spaceflight can be very useful to science." ■

Scientists Chosen as USML-2 Payload Specialists

The 16-day Spacelab mission, planned for STS-73 in September 1995 aboard the Space Shuttle Columbia, will carry the second United States Microgravity Laboratory (USML-2) and focus on materials science, biotechnology, combustion science, the physics of fluids and many other scientific experiments. It will become the longest mission in Space Shuttle program history.

NASA has announced the assignment of Dr Albert Sacco, Jr and Dr Fred Leslie as the two payload specialists and Dr David H. Matthiessen and Dr R. Glynn Holt as their backups.

Dr Albert Sacco, Jr. NASA

Dr Albert Sacco, Jr, 44, was an alternate payload specialist for the highly successful USML-1 mission on STS-50 in June and July 1992. At the same time he was principal investigator of the USML-1 Zeolite crystal growth and glovebox experiments. He is head of the Chemical Engineering Department at Worcester Polytechnic Institute and has authored more than 50 publications on carbon filament initiation and growth, catalyst deactivation, and zeolite synthesis.

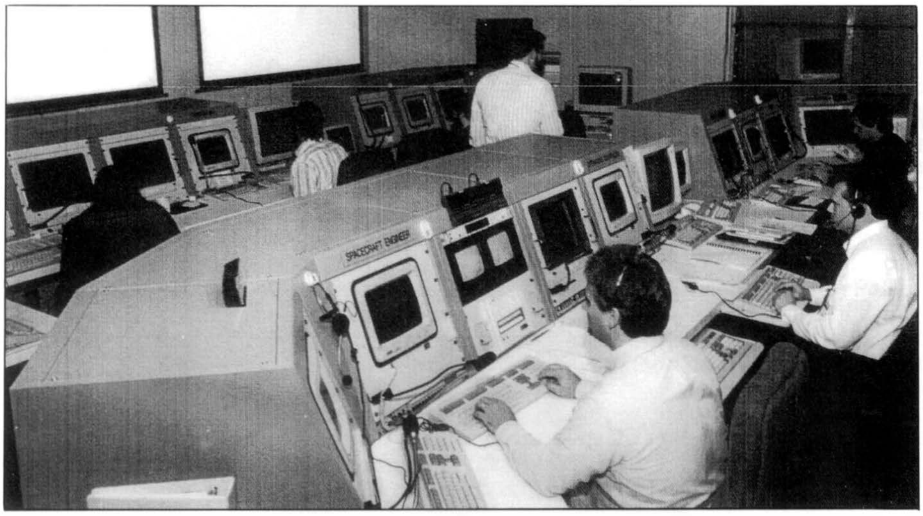
Dr Fred Leslie, 43, is a scientist of the NASA Marshall Space Flight Center in Huntsville, Alabama, where he is deputy chief of the Earth System Science Division.

Dr David H. Matthiessen was principal investigator of a USML-1 gallium arsenide (GaAs) growth experiment in microgravity. GaAs is a technologically important semiconductor used in a variety of applications.

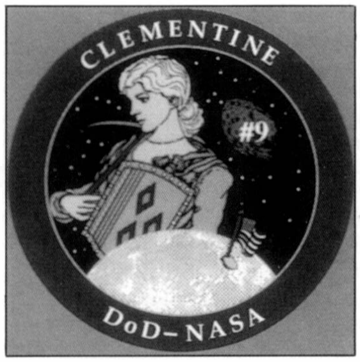
Dr R. Glynn Holt was co-investigator for the *Drop Dynamics Experiment* on that flight.

So far two NASA-Astronaut crewmembers have been named for STS-73/USML-2: payload commander Dr Kathryn C. Thornton, PhD and mission specialist Dr Catherine G. Coleman, PhD (Captain, USAF). More assignments (commander, pilot and one more mission specialist) are expected at a later date.

ROLF H. SCHOEVAART, THE NETHERLANDS



Clementine Mission Control Center located in the suburbs of Arligton, Virginia. NRL



BY DARREN L. BURNHAM
Oxford, UK.

Faster, Cheaper, Clementine
Around the Moon in 71 Days

It was George Bush who once set out to take the US space programme "back to the future". What Bush had in mind was a loving re-creation of the grand gestures of the Apollo era. How ironic then that the President's philosophy should have come to be best embodied by a small inexpensive robotic probe.

With the launch of the Clementine probe in January 1994 the US space programme came full circle. Back in a time of apparent crisis in the late 1950s it was the military which oversaw the launch of America's first lunar probes. Symbolically, albeit in very different circumstances, it was the military which again led the path back to the Moon over thirty years later. Adding to the sense of déjà vu, Clementine also represented a return to the days of small spacecraft built by government funded laboratories and flown at a pace which provides a quick return on investment [1].

Unfortunately, plans for Clementine to follow its lunar observations with a close flyby of a near-Earth asteroid had to be abandoned. Nevertheless, in spite of this disappointment the mission as a whole has been rated as a success and the process of digesting what lessons can be learned from the Clementine programme is only just beginning.

Past Imperfect

The Clementine spacecraft really owes its existence to the cold war. In January 1983 President Reagan went before the American people to speak of his desire to develop a space based defensive shield which would protect the United States from enemy Intercontinental Ballistic Missiles (ICBM's).

Few outside of a small circle of advisers knew of Reagan's intentions, and the plans immediately drew a hostile response from many respected scientists who regarded the development of such an impregnable shield as an unattainable goal. Reagan pressed ahead anyhow and a few months later the Strategic Defense Initiative Organization (SDIO) was formed. Housed by the Pentagon, and handed a multi-billion dollar budget, the remit of the new organisation was to begin the development and testing of the technology from which such a shield might one day emerge.

A decade is a very long time in geopolitics. As we know, the Iron Curtain rusted away and then collapsed under its own weight, turning the old-world order on its head in the process. Not long after the threat of an all-out nuclear attack disappeared, so did SDIO. In 1993 it was renamed the Ballistic Missile Defense Organization (BMDO) by President Clinton and told to focus on the development of more modest ground based defensive systems. Its main programmes are now the Ground-Based Radar and the Theatre High Altitude Area Defense (THAAD) systems.

The change in direction came too late to affect plans for the Clementine mission, or the Deep Space Program Science Experiment (DSPSE) as it is officially known in Defense Department circles. In common with the MSTI (Miniature Seeker Technology Integration) spacecraft launched in November 1992 and May 1994, the *raison d'être* of the Clementine mission was to flight-test a series of new lightweight spacecraft subsystems and sensors. Originally such hardware was planned for use on the Brilliant Pebbles missile interceptors and Brilliant Eyes missile tracking satellite constellations.

While preparing the mission the engineers faced one obvious problem: finding targets which would rigorously test the capabilities of the sensors. This problem was neatly solved by a decision to send the spacecraft beyond the realm of low Earth orbit (LEO) on a trajectory which would first send it to the Moon and then past a near-Earth asteroid.

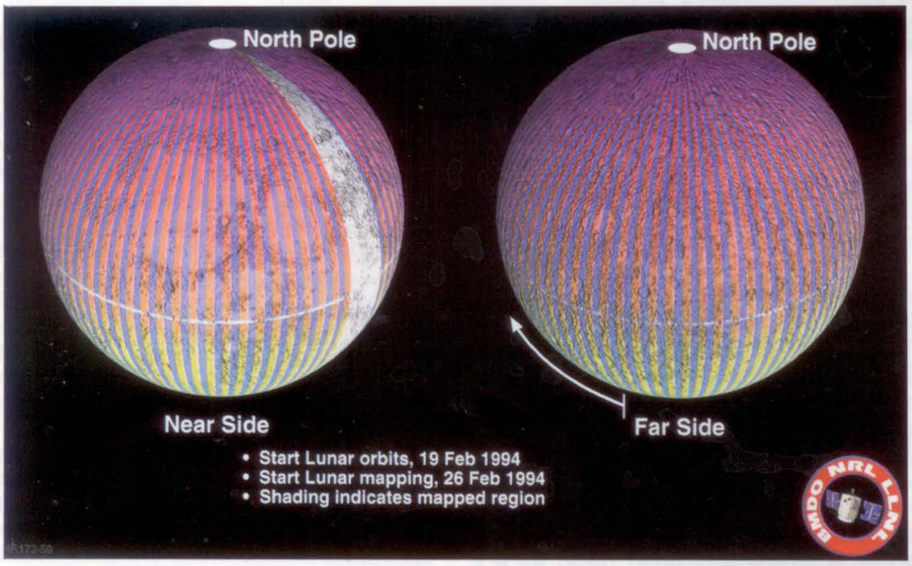
Sending the spacecraft hurtling towards an asteroid might not seem the most obvious way of saving money, but in this instance there is method in such madness. Besides testing the optical capabilities of the new sensors Clementine's designers also wanted to determine how well the hardware would withstand the effects of solar and cosmic radiation. At the very least this entailed putting the satellite into a geosynchronous orbit, or in an eccentric orbit where it would have continually dipped in and out of the Van Allen radiation belts. However, had this been done it would have been necessary to spend $10 to 15 million to provide artificial targets for Clementine to observe. This being the case it made more sense to push a little further into Earth's backyard where natural targets could be found for free. Such a "deep" space test also avoided any problems which might have arisen with regards to non compliance of the Anti-Ballistic Missile Treaty signed by the US and USSR in 1972.

Shotgun Wedding

Recognizing that a Moon/asteroid mission might also make worthwhile scientific observations SDIO invited NASA to play a role in the mission. The idea was warmly greeted by NASA scientists who could now look forward to some unique data about the Moon and the first close-up look of a near-Earth asteroid. Various concepts for low cost missions to the Moon have been kicking around NASA for a number of years, but these ideas remain unfunded. With its probes stuck firmly to the drawing board the space agency had little hesitation in taking the opportunity to cooperate with SDIO. Though NASA contributed nothing to the development of Clementine's hardware,

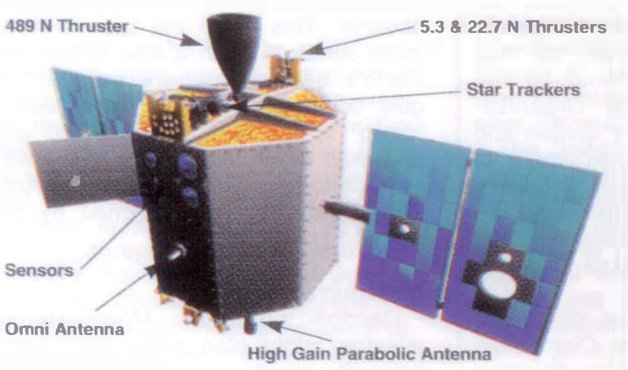
Right: **Launch of the Clementine spacecraft aboard a Titan 2 rocket on 25 January from the Vandenberg Air Force Base. The Clementine mission was dedicated to the late Gerard K.O'Neill.** NRL

Below: **Status of lunar mapping as of 2400 UT (Z), on 24 March. Primary mapping was completed by the 297th orbit on 22 April with some fill-in imaging completed in the following days.** NRL

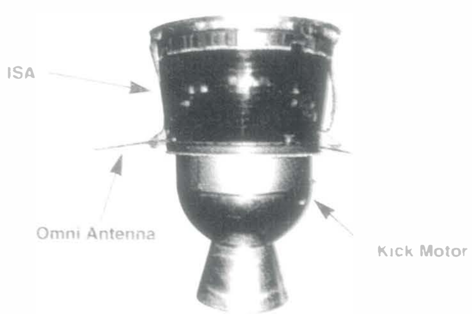


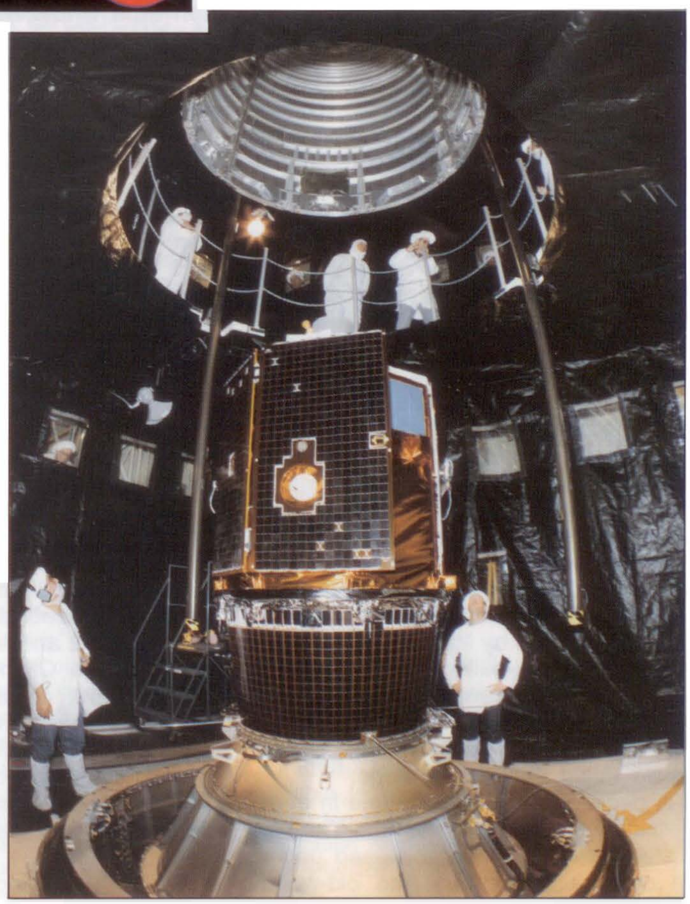
Below: **Clementine was developed by the Naval Research Laboratory, Washington, DC and the Lawrence Livermore National Laboratory, Livermore, California. It is shown here in the clean room being integrated with the interstage structure.** NRL

DSPSE Spacecraft



DSPSE Interstage Adapter System





the Goddard Space Flight Center, the Jet Propulsion Laboratory and the Deep Space Tracking Network (DSN) all helped to support the mission. NASA is also funding scientists to analyse the data returned by the probe.

Clementine should serve as an encouraging example for a number of smaller missions which NASA is planning as part of the Discovery programme [2]. NASA has been attempting to downsize its spacecraft for several years and the Clementine programme has given it valuable hands on experience with a whole host of micro technologies developed to meet the needs of the SDIO. NEAR, NASA's own Discovery class asteroid probe is making good progress towards a 1998 launch.

Bringing It All Back Home

Though the analogy with the early space probes makes for some good attention grabbing copy, in reality it is something of a misnomer. A return to antediluvian Explorers and Pioneers would benefit nobody today. It must be remembered that these spacecraft were launched in an era when so little was known about space and the planets that virtually any instrument, however basic, bolted to a spacecraft could yield significant results. However, needs have come a long way since then but so has technology. The Explorers and Pioneers belong to an era when televisions and radios still used valves. Clementine is a product of the age of the camcorder and laptop computer. Small in stature the spacecraft may be, but its performance can still outstrip that of many more sizable competitors.

Computer performance is always a reasonably reliable yardstick to the maturity of a spacecraft. Clementine is equipped with a 32-bit RISC commercial computer with a R3081 processor and a solid state recorder with a mass storage capacity of 1.6 Gbyte. It is claimed that this is four times the capacity of any solid state recorder previously flown. This is used in conjunction with a Joint Photographic Expert Group (JPEG) chip set which was supplied by Matra Marconi and can achieve a 10:1 compression ratio.

Other innovations include a pair of Star Trackers each weighing only 370 grams, a Reaction Wheel which weighs just 2 kg, and two Inertial Measurement Units weighing 600 grams and 500 grams each. Clementine also boasts the lightest solar cell arrays ever flown. At 0.14 mm thick the cells have a power density ratio of 301 watts per square meter - more than doubling the best power density ratio achieved in the past.

The jewels in Clementine's crown are the cameras and sensors which were designed and developed by the Lawrence Livermore National Laboratory, of Livermore, California. Details of these appear below.

If there is any one failing with the optical sensors it is that they have more noise and less signal than scientists would prefer, but most scientists were just happy to have the opportunity to end their lunar data famine.

Clementine also carries a Charged Particle Telescope (CPT) which was provided by the Aerospace Corporation. The interstage adaptor carried four solid state dosimeters for radiation measurements, a single event upset/total dose detector and a variety of new avionics components being tested in space for the first time.

Anyone with an interest in space exploration must soon learn to come to terms with some pretty mind boggling statistics, but in some respects these figures beat the lot: Clementine was developed at a cost of $55 million in less than two years by a team of 55 engineers. The spacecraft was built by the Naval Center for Space Technology, a division of the Naval Research Laboratory (NRL) which is based in Alexandria, Virginia.

Not everything associated with Clementine's development went smoothly. Designers had set themselves the goal of producing a spacecraft with a dry mass of 160 kg but the finished article ended up being 230 kg. Both the LWIR and NIR cameras failed during vibration testing and each had to be rebuilt twice, delaying delivery by three months. Problems were also experienced with the computer which became overloaded while processing inputs from the star trackers. These problems were overcome by re-writing the software [3].

Bound for Glory

The Clementine programme was the recipient of a former Titan ICBM which was refurbished for use as a space launch vehicle at a cost of $20 million. The launch took place from Pad SLC-4W at the Vandenberg Air Force base in California on January 25, 1994. The Titan 2G began its rise into a bright near-cloudless sky at 8:34 AM PST. It was the first occasion on which the west coast launch site had been used to launch a lunar probe and Clementine would in due course become the first US probe to be placed in lunar orbit since Explorer 49 in June 1973. Initially it was placed in a 255 x 300 km Earth parking orbit with an inclination of 67 degrees.

The first few hours of the mission provided some anxious moments. Operational control rested with NRL facilities in Virginia and Pomonkey, Maryland, with a miscellany of Air

Clementine cameras and sensors. LLNL

A unique imaging ***Star Tracker*** provides an inertial reference for the spacecraft by comparison of star field images with an on-board star map. Two such instruments were flown on Clementine.

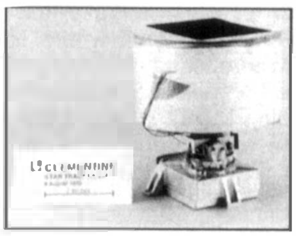
The medium resolution ***UV/Visible Camera*** uses Silicon CCD technology and a six position spectral filter wheel and is suitable for remote sensing applications such as lunar mineralogical studies.

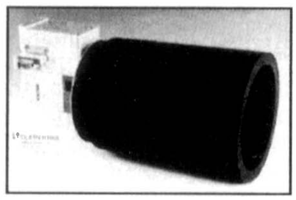
The medium resolution ***Near-Infrared Camera (NIR)*** uses a coated InSb array and a six position spectral filter to extend remote sensing and mineralogical studies into the near infrared.

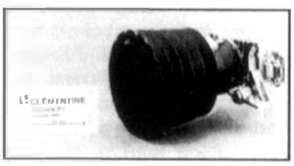
The ***High Resolution Camera (Hi-Res)*** operates at visible wavelengths with Silicon CCD technology combined with a compact image intensifier and a six position spectral filter wheel to provide images free from spacecraft motion blur.

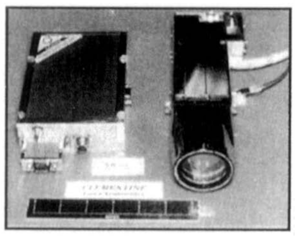
The ***Laser Transmitter*** operates in conjunction with the LIDAR receiver and the optics of the High Resolution Camera to obtain altitude measurements during mapping orbits around the Moon.

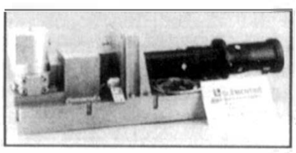
The ***Long Wave Infrared Camera (LWIR)*** uses current Mercury Cadmium Telluride array technology to provide a lightweight camera to measure the thermal emissions from the Moon.

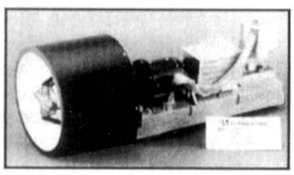

Star Tracker


High Resolution Camera/ LIDAR Receiver


Uv/Visible Camera


Laser Transmitter


Near Infrared Camera


Long Wave Infrared Camera

An image of the Rydberg Crater of 35 km diameter at latitude 46°S, longitude 96°W taken by the Near Infrared Camera through the 1.50 µm filter from an altitude of 460 km. NRL

Force, Navy, NASA, and ESA ground stations being used to track the spacecraft while it was in LEO. Unfortunately, the ground segment was not yet running as a well oiled machine and Clementine did not receive the commands telling it to switch off various electrical subsystems. This almost had dire consequences for the mission, for with the solar arrays still stowed it seemed as if the spacecraft's battery might become depleted. Had Clementine been equipped with a conventional nickel-cadmium battery the spacecraft might well have expired in this situation. To the relief of all involved, the new nickel-hydrogen common pressure vessel battery which Clementine carried proved to be more tolerant and the mission was able to continue.

On orbit checks gave the spacecraft a clean bill of health and on February 3 Clementine's solid rocket motor was fired to send the spacecraft on its perambulating path towards the Moon. Insertion into a 425 x 2,940 km lunar orbit was completed on February 21.

The spacecraft soon began sending back data which far surpassed much of that obtained during the Apollo programme both in terms of quantity and quality. Each five hour orbit yielded an average of 4,000 to 5,000 digital images. Primary mapping was completed by the 297th orbit on April 22, with some fill-in imaging completed in the days which followed.

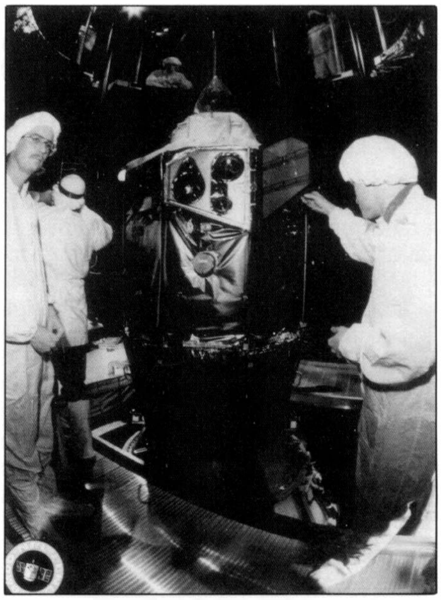
The 303rd orbit was especially significant. On this orbit Clementine carried out a mapping sequence by itself. Planning the mapping time-line, calibrating the near-infrared camera and choosing exposure times was all carried out autonomously - the first occasion on which a spacecraft had attempted to do such a complex task by itself [4].

In all more than 1.6 million images were gathered during the time in lunar orbit. One of the great innovations of the mission was that images were placed on the Internet. This allowed any scientist with the appropriate hardware and software to log in and gain access to the raw data. The total volume of data returned by Clementine during the lunar mapping phase was comparable to that transmitted by Magellan during the first radar mapping cycle of Venus.

The spacecraft began the global multispectral mapping of the Moon which has been a pressing need ever since the end of the Apollo programme. Though the Moon has been more closely explored than any other body in the Solar System data was previously restricted to the groundtracks of the Apollo Command Modules and ground truth data obtained at the Surveyor, Luna and Apollo landing sites. The Clementine data also includes topographic profiles for the middle latitude band (+/- 60°) and a geodetic database for the whole surface.

The lunar mapping occurred in two distinct phases. Initially the spacecraft was in an orbit where its lowest point was reached at 30 degrees south latitude. A series of manoeuvres performed on March 25 and 26 moved the perilune to 30 degrees north.

In a first of a kind experiment, Clementine also attempted to take a look for ice deposits at the Moon's poles. This was done by emitting a pure sinusoidal carrier signal from the spacecraft's 1-meter diameter S-band antenna. The signal was reflected off the lunar surface and then picked up by the antennas of the DSN on Earth. An initial attempt to perform the bistatic radar observations was made in March but was halted when problems with the DSN were discovered. The tests were successfully resumed in April [5]. Initial analysis seems to confirm the existence of ice at the poles, although the final results may not prove conclusive either way.



The optical instrumentation ports and their cover being examined by a technician during preparations in the clean room. BMDO/NRL/LLNL

Asteroid Hopes Dashed

When Clementine fired its bipropellant thruster for 270 seconds on May 3 to boost it out of lunar orbit all seemed set fair for the flyby of Geographos in August 1994. Hopes for a smooth passage to Geographos were dashed on May 7 when an indeterminate problem arose with the software which was being tested at the time in preparation for the flyby. This set in motion a chain of events which drained the spacecraft of its supply of hydrazine propellant.

As a result of the unplanned thruster firings the 3-axis stabilised spacecraft was left spinning at 80 rpm. Flight controllers eventually managed to bring this down to 30 rpm, but such skittish behaviour still rendered Clementine's senors useless, meaning there was little point in attempting the asteroid flyby. Instead the decision was taken to place the spacecraft in an eccentric Earth orbit where it can be used to study the degradating effects of radiation for a further two years [6].

Dawn of a New Era?

If nothing else, the Clementine pro-

Asteroid Flybys that Never Were

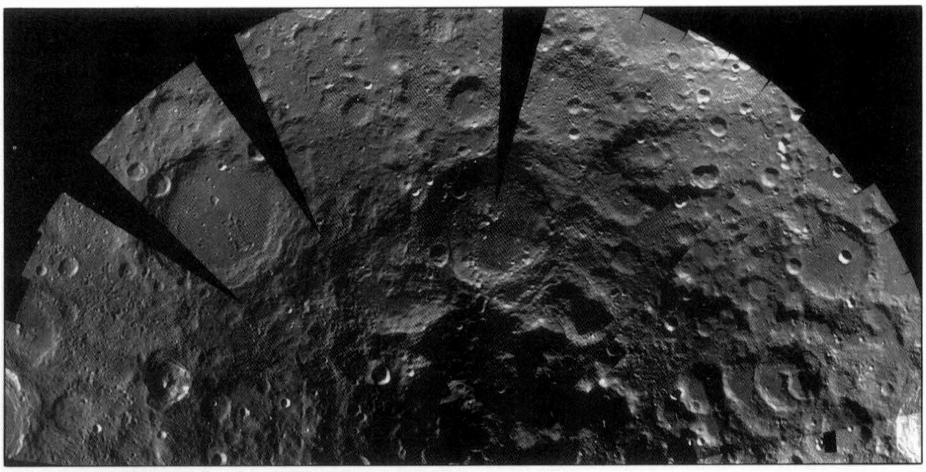
The Clementine mission really should have been a game of two halves, but time was called on the planned flyby of asteroid Geographos when the spacecraft was debilitated by the loss of its stabilising fuel.

Asteroid 1620 Geographos is classified as a stony Apollo type asteroid and as such travels inside the orbit of the Earth. The asteroid was first discovered in 1951 using Palomar Observatory's 48-inch Schmidt telescope during a sky survey sponsored by the National Geographic Society (in honour of which the asteroid gained its name). Earth based observations suggest that the asteroid is some 3 to 4 km long and 1.5 km in diameter, with a rotation period of five hours. Given its apparent dumbbell shape it has been speculated that the asteroid may in fact be two objects which form a "contact binary" pair [8,9].

Had problems not beset Clementine so early in the mission, the spacecraft might also have been billeted to make a flyby of the asteroid 1983RD. This would have occurred in October 1995, pending modifications to the DSN.

gramme has been a major public relations coup for the Department of Defense. The programme seems to have been the darling of the aerospace media right from day one. The fact that the asteroid phase of the mission was not completed has hardly made a difference to this perception, as the growing list of glowing testimonials attests [7].

Promising though some aspects of Clementine's mission have undoubtedly been, it is advisable to keep things in their proper perspective. A short hop to the Moon is hardly in the same league as probing the Jovian atmosphere or returning samples from a comet. It is worth considering that had Clementine been heading out towards Mars that the end result would have been much the same as the Mars Observer, but having said this, it is much less painful to lose a $55-million spacecraft than one costing $500-million.



Clementine mosaic view of the lunar south pole. NRL

It is too early to say whether Clementine represents the dawn of a bright new era for US planetary exploration, but there are many who would claim that if the lead is not followed then the sunset might not be long in arriving.

Clementine 2: A Leap of Faith?

Small, innovative spacecraft programme seeks $70 to 80 million to fund second flight in series - that is the dilemma facing the team responsible for the first Clementine mission.

A second Clementine mission has always been on the cards. The programme was structured for two satellites and two sets of hardware were ordered by SDIO. Unfortunately the mission is unlikely to ever be sanctioned. In spite of all the considerable achievements the programme has clocked up to date, in spite of perfectly embodying the Clinton Administration's hopes for a leaner, more productive space programme, the Clementine programme has fallen from grace and is now effectively *persona non grata* with most of the movers and shakers in Washington.

The mission would represent one of the more unexpected examples of turning swords into ploughshares. The mission would most probably carry 2 or 4 probes which could be fired at the surface of either the Moon or an asteroid. The probes are known as Light Exoatmospheric Projectiles (LEAP) and were originally designed as missile interceptors, but dressed in "civvies" the interceptors would become asteroid penetrator probes or lunar soft landers.

Initially an asteroid mission was favoured, and a number of targets were considered for the flight including Eros and Toutatis. The plan was to fire the probes towards the surface, causing rock and soil to be vaporised for analysis by the sensors aboard the main spacecraft. In the alternative lunar mission proposal which now holds the greater appeal, the probes would be adapted to soft land on the surface. They could carry a variety of scientific instruments or even deliver small micro-rovers [10].

To allow Clementine 2 to carry the interceptors the spacecraft's structure would be made from a lightweight composite material and fibre optic cabling would replace conventional wiring. The Thiokol Star 37 FM solid rocket motor used to boost Clementine 1 out of LEO would also be substituted for a higher energy Advanced Liquid Axial Stage (ALAS) developed by Aerojet.

On paper it seems like an ideal compromise. The engineers still get to test the performance of the interceptors, the scientists gain access to some pretty unique data - everybody's happy.

The problem is that everybody is not happy. The BMDO which was once behind the mission now has no need for such a flight. Its horizons have been cast downwards and Brilliant Pebbles has been shunted to the bottom of its list of priorities. Claims by programme managers that Clementine's micro-technology is also applicable to ground based missiles have so far fallen on deaf ears. Given that $20 billion has been slashed from BMDO's spending plan through to 1999 its hardly surprising that there is barely a cent to spare for less essential projects. Read DC-X for Clementine and the story is much the same.

Within NASA the mission seems to be suffering from the "not invented here syndrome". In all fairness, the space agency has more than enough low cost missions of its own competing for funding at the present time, and Clementine's prospects are not helped by the fact that its design has not been optimised for scientific data collection. At one point Clementine 2 was tabled by BMDO as a quick and cheep replacement for the failed Mars Observer, but NASA thought the MSTI programme represented a more viable option [11]. In the event, however, NASA went down its own road by opting to develop the Mars Surveyor concept for a 1996 launch instead.

Several other departments of the military have shown interest in the Clementine programme. Both the Air Force and DARPA were mentioned as potential managers before the decision was taken to transfer authority for the programme to the Navy. However, apart from an additional $3.2 million channelled to fund the continuation of the Clementine 1 mission for the remainder of 1994, the Navy will have to fund the programme out of its own budget. Long odds are now being laid on the chances of the Clementine 2 mission ever taking place.

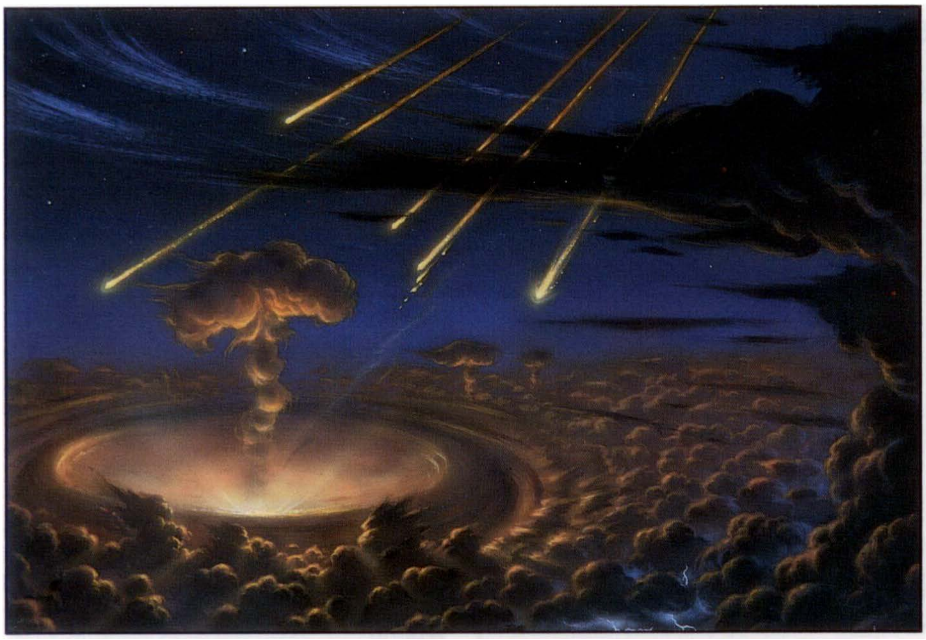
Acknowledgements

The author gratefully acknowledges the contributions of the following to the completion of this article: Jim Campbell (Clementine Program Manager, NASA), Paul Lucey (University of Hawaii, Honolulu), Marcia Smith (The Library of Congress, Washington), and the Public Affairs Branch of NRL.

References

1. Andy Salmon, "Oh My Darling Clementine", ***Spaceflight***, 35, No. 7, July 1993, p.245.
2. "NASA Plans New Solar System Missions", ***Spaceflight***, 35, No. 5, May 1993, p.151.
3. "Clementine to Mark U.S. Return to Moon", *Aviation Week & Space Technology*, January 17, 1994, pp.66-67.
4. "Clementine Ends Lunar Mapping", *Aviation Week & Space Technology*, May 2, 1994, p.21.
5. "Clementine to Search for Ice at Lunar Poles", *Aviation Week & Space Technology*, April 11, 1994, pp.28 and 29.
6. "Sensors Misdirected; Clementine To Forgo Geographos Fly-By" *Space News*, May 23-29, 1994, p.22.
7. Eric R. Sterner, "Clementine: Faster, Cheaper, Better", *Space News*, January 24-30, 1994, p.21.
   "Give Clementine 2 A Fair Shot", *Space News*, April 25 - May 1, 1994, p.14.
8. Clifford J. Cunningham, "Introduction To Asteroids - The Next Frontier", Willmann-Bell, Inc., Virginia, 1988.
9. Stewart Nozette and Eugene M. Shoemaker, "Back to the Moon, on to an Asteroid", Planetary Report, Vol. XIII, No. 5, September/October, 1993, pp.10-15.
10. "Low-Cost Spacecraft Begins Mapping Moon", *Aviation Week & Space Technology*, March 7, 1994, pp.20 & 21.
11. "Clementine Rejected As Replacement for Mars Observer", *Space News*, November 8-14, 1993, p.8.

Orbital data are taken from *Satellite Digest*, prepared by Phillip S. Clark, ***Spaceflight***, 36, Nos. 4 and 5, April and May 1994.



Space artist David A. Hardy portrays the impacts of Comet SL-9 on Jupiter as viewed from cloud top height in this picture entitled 'Comet SL-9/Jupiter Impact III'. © DAVID A. HARDY

Comet Fragments Impact Jupiter

Line-of-Sight View from Galileo Spacecraft

The impacts of Comet Shoemaker-Levy 9 into Jupiter occurred over a period of five-and-a-half days. For the first time an astronomical observing programme made extensive use of the Internet computer network, providing the opportunity for near real-time interactions between observers on a global scale. The European Southern Observatory at La Silla, Chile was one of the centres that undertook extensive observations of Jupiter between 16 and 23 July. Their assistance in providing information for inclusion in this report is gratefully acknowledged.

Discovered in March 1993, Comet Shoemaker-Levy 9 was found to have broken into more than 20 fragments during its July 1992 close passage of Jupiter All fragments, ranging from a few hundred metres to a few kilometres in size, approached Jupiter along the same straight-line path and impacts took place at very nearly the same position relative to the centre of the planet, i.e. at 45 degrees S latitude and 4 to 9 degrees in longitude behind the planet's limb as seen from the Earth. Their direction of approach was almost exactly from the Jovian due south direction, striking the atmosphere at an angle of about 45 degrees. On account of Jupiter's rotation, the impacts formed a patchy belt around the planet.

Predicted impact times turned out to be accurate to with a few minutes, the actual impacts coming several minutes later than expected due to the limiting arcsecond accuracy of the background reference stars. Post-impact analysis secured impact times to about 1.5 minutes either way.

Some of the impact flashes were observed by the Galileo spacecraft which, although still 240 million km away, had a line-of sight view of the impact points. As Galileo's high-gain antenna in out of order, it will take at least a month to relay data back via its slow data-rate antenna.

It was expected that impact flashes would be observed from the Earth by reflection off the Jovian moons, but this was apparently not possible. Some impact flashes were however observed from the ground due to refraction in the Jovian atmosphere bending light around the planet's limb.

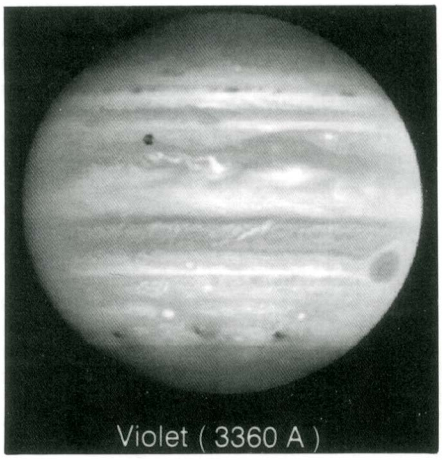
All impacts produced a craterlike structure in the cloud deck of Jupiter at UV as well as at visible wavelengths and there are indications of rings propagating outwards from the impact site. The central 'hole' of the crater consists of material with low reflectance and, although these impact features are being sheared by Jovian winds, impact sites were still marked by dark spots along the line of the impact latitude several days later and could persist for some time. One of the surprise effects of the impact of SL-9 with Jupiter was that these conspicuous dark features were seen in visible light. The Hubble Space Telescope has been observing the dark areas left behind as it offers the highest resolution images and the possibility of spectral analysis.

From all but two impacts, rising plumes have been observed at IR wavelengths. Within about an hour however the plume collapses into a flat pancake-like structure, which is typically the size of the Earth or bigger. The plume is transparent at visible and UV wavelengths and fades quicker at longer IR wavelengths than at shorter IR wavelengths.

Of the 21 fragments impacting Jupiter, the seventh, fragment G, was the largest with an estimated diameter of 3.25 km and created a plume that rose to a height of 1600 km.

After the last impacts, a new phenomenon was discovered at the European Southern Observatory at La Silla: the appearance of bright IR features in the northern hemisphere, exactly opposite, with respect to the equator, of the large impact sites in the southern hemisphere. While there is a possibility that these are seismic waves which have travelled through the planet, it is current thinking that the features are caused by the transport of material, which was lifted up by the impacts and guided to the northern hemisphere by the very strong Jovian magnetic field to produce an auroral-like effect.

During the impacts almost all effort was spent on collecting data and results have been of a preliminary nature. The European Southern Observatory has drawn up a coordinated programme for calibrating observations and storing them in a database and will be deciding with all collaborators on the most effective data analysis strategy. The data analysis process will take of the order of half a year and several further months will be needed to reconcile the new facts and existing theories. ■



Above: **Impact sites of fragments C, A and E (left to right) are seen at about 12, 23 and 4 hours after each collision in this Hubble image of Jupiter. Also seen are the satellite Io and the famous Great Red Spot.**
JOHN CLARKE, UNIVERSITY OF MICHIGAN/NASA

Below: **A Hubble image showing the large feature created by the impact of fragment G. The smaller feature to the left of it was created by the impact of fragment D.**
H. HAMMEL, MIT/NASA

COSPAR '94, Hamburg

Mars Armada: 1996-2003

"The future of Mars exploration is now receiving more attention than the next moves in a return to the Moon", the July 1994 COSPAR meeting heard.

Mars Global

In spite of the major setbacks in missions to Mars - the failed approach of the American Mars Observer and the delayed launch of the Russian (and international) Mars 94 probe - there are, up to 25 various spacecraft in preparation or in planning stages for launches during 1996-2003 from Baikonur, Cape Canaveral and Kagoshima. This international approach is named *Mars Global* and these 25 spacecraft or elements of Martian probes will allow a permanent international presence after 1997 (the 40th anniversary of Sputnik) around Mars and on the Martian surface.

In late 1996 - and making a fine celebration of the 20th anniversary of the Vikings on Mars - will be the start of the new phase in the exploration of Mars. Robots in the form of orbiters, landers and rovers in mini and micro format will be sent to the Red Planet between November 1996 and January 1997. They will be followed, at each launch window - every two years - to Mars, by many other automated spacecraft.

The session at the COSPAR Assembly about future Mars exploration gave the following calendar of operations related to international cooperation for a permanent presence on Mars. However, there are no plans to send manned vehicles to the Red Planet and it was not made clear how ESA would contribute to this return to Mars.

Spacecraft Armada

November 1996: Launch by Proton from Baikonur of the Mars-96 spacecraft, carrying the payload of Mars-94, developed by NPO Lavochkin. Planned arrival at Mars in September 1997.

- Landing, with the help of aeroshield and parachute, of two small stations equipped with cameras, spectrometers and meteorological sensors.
- Dropping into the Martian surface of two penetrators, each carrying a camera and miniaturised sensors.
- Orbiter with cameras, sensors and relay systems, placed around Mars.

November 1996: Launch by Delta II from Cape Canaveral of Mars Global Surveyor, a low-cost and light spacecraft developed by Martin Marietta Technologies Inc to replace the lost Mars Observer. Planned insertion into Martian polar orbit with aerobraking process in September 1997.

- Carrying a portion of the Mars Observer instrument payload to acquire pictures and data for mapping and environmental studies during a full Martian year (= two Earth years) in a two-hour "Sun-synchronous" orbit.
- Designed as a relay station for data from Martian landers and rovers for an additional three Earth years.
- Described as the first mission of a new, decade-long programme of robotic exploration of the Red Planet.

December 1996: Launch by Delta II from Cape Canaveral of Mars Pathfinder, the first of the Discovery-class family of low-cost and low-weight planetary landers. Direct entry in the atmosphere and landing on the surface of Mars in July 1997. It will be the first probe to land on Mars after the superb mission of the Viking landers during the second half of the 1970s.

- Technological spacecraft testing miniaturised systems for the exploration of the Solar System.
- Payload consisting of stereoscopic imager, spectrometer, meteorological package and if it is funded (by an extra $22 million for a total budget of $150 million) - the 6-wheeled Rocky IV microrover, which will be equipped with close-up imaging capacity and X-spectrometer.
- Instruments planned to function on the surface of Mars from 30 days to one year.

August 1998: Launch by M-V from Kagoshima of the 258 kg Planet-B probe. Injection after swing-by manoeuvres close to the Moon and the Earth into a transmartian trajectory on December 1998. Arrival in the orbit of Mars, planned for October 1999.

- Carrying a 33-kg science payload, consisting of 15 instruments (from Japan, Sweden, Canada, Germany and USA) to study the upper atmosphere, the magnetic field and dust environment of Mars.
- Stimulating the development in Japan of micro-miniaturised technology for further spacecraft to be launched in the Solar System.

January 1999: Launch by Proton of Mars-98 spacecraft, to achieve the former mission of Mars-96.

- Carrying the Marsokhod, a 100-kg Mars rover with a 14-kg payload, powered by Radioisotope Thermal Generator (RTG), designed for 1-year lifetime to cover a range of 100 km on Mars.
- Dropping from the descent module two sounding balloons equipped to study the Martian atmosphere and to survey the surface of Mars with cameras and spectrometers.

January 1999: Launch by Delta II of two New Landers, derived from the technology of the Pathfinder or one New Lander (in the polar region) plus one Global Surveyor.

Spring 2001: Launches by Delta IIs or MLV-Lite of two to four New Landers, to establish a network of scientific stations, with microrovers, on various sites of the Martian surface.

Late 2002: Projected launch by improved M-V from Kagoshima or by H-2 from Tanegashima of an interplanetary probe to collect a sample on an asteroid near Mars and to return it to the Earth. Injection in transmartian orbit in Spring 2003 for an arrival to Mars one year later.

May-June 2003: Projected launch by improved Proton or by Energiya-M of the Phobos-type spacecraft for the international Phobos Sample Return Mission. Arrival to Mars in March-April 2004. Launch from Mars in July-August 2005 for an arrival close to the Earth in March-April 2006.

May-June 2003: Projected launch by improved Proton of the Mars 2003 spacecraft to carry two small stations, two penetrators and one Marsokhod.

May-June 2003: Projected launches from USA of one Global Surveyor for mission in Martian orbit and of two New Landers for further in situ investigations on the Martian surface.

July 2003: Planned launch by Ariane 5 from Kourou of the ESA spacecraft (Mariner Mark II platform) for the international Rosetta Comet Rendezvous Mission to achieve in situ analysis of cometary matter.

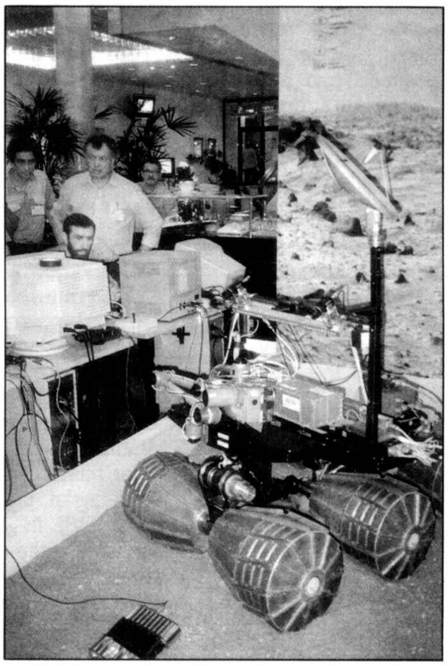
- Utilising one gravity assist with low-altitude flyby of Mars during spring 2006. Possibility of transmitting pictures and data about the Martian environment.
- Approaching a comet in 2012-2014, mapping its nucleus and releasing for descent two surface packages with remote imaging system, spectrometer and analysers.

THEO PIRARD

Mars Observer Lessons

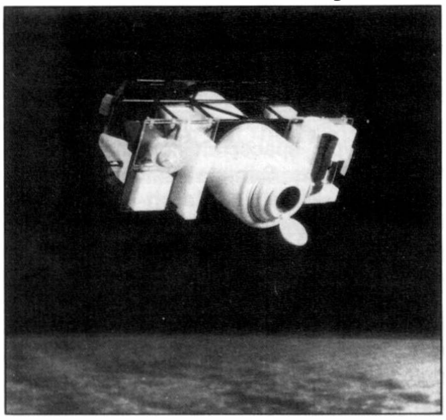
NASA has issued a 257-page report entitled Mars Observer Corrective Action Plan which identifies lessons learned from an evaluation of the Mars Observer failure review and determines specific actions to be taken by the Agency to prevent failures such as the Mars Observer in the future.

Demonstrating the manoeuvrability of the Mars rover at COSPAR '94. Th.P./SIC



Second ASTRO-SPAS Mission

New Eye on Earth's Atmosphere



The cylindrical CRISTA instrument mounted on the ASTRO-SPAS platform.

In October 1994, as part of NASA's Mission to Planet Earth long-term global-research programme, the Space Shuttle Atlantis will transport a battery of Earth-observation sensors into orbit, fitted to a recoverable free-flyer. Known as 'ASTRO-SPAS', the craft is an advanced version of the original Shuttle Pallet Satellite 'bus', which has been used on numerous occasions to provide scientific instruments with several days of untended activities at a distance of some kilometres from the Shuttle.

The two primary instruments mounted on the ASTRO-SPAS platform for this mission are known as the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere (CRISTA) and the Middle-Atmosphere High-Resolution Spectrograph Investigation (MAHRSI). Together these instruments will observe the 'middle atmosphere' region, between the altitudes of 10-150 km above the surface, over an eight-day period.

BY BEN EVANS
West Midlands, UK

SPAS and ASTRO-SPAS

ASTRO-SPAS, to which the CRISTA/MAHRSI combination will be attached, is an upgraded version of the original SPAS-01 platform, which underwent its first orbital test-flights in June 1983 and February 1984. These missions evaluated the performance of the craft, but the Challenger disaster two years later prevented the system from reaching fully-operational status until 1991.

The second-generation ASTRO-SPAS system has evolved directly from its earlier counterpart, but its capabilities are much improved in that it can spend between four and eight days in untended free-flight and achieve distances of up to 120 km from the orbiter. It has also permitted the installation of larger payloads on the SPAS platform.

ASTRO-SPAS consists of a series of low-weight and high-stiffness carbon-fibre compound tubes, connected by titanium nodes, and the overall structure is enshrouded with white thermal insulation blankets. 'Standard' mounting panels are provided on the free-flyer's upper surfaces for instruments, instrument-support equipment, and other related subsystems. Electrical power for the payloads is provided by a lithium battery-pack, of which each battery produces 10 kW. A total of two to five such batteries are allocated to the payload, depending upon the mission.

The First CRISTA/MAHRSI Mission

The second ASTRO-SPAS free-flyer, carrying CRISTA and MAHRSI on their maiden mission, is scheduled for deployment from Atlantis during Day Two of the eleven-day STS-66 mission. The upberthing and release of the satellite will be performed by ESA Mission Specialist Jean-Francois Clervoy by means of the Shuttle's Remote-Manipulator System (RMS) mechanical arm, after which Atlantis' Commander will manoeuvre away from the payload. For the next eight days, until the satellite is retrieved by Payload Commander Ellen Ochoa on Day Ten, ASTRO-SPAS and its instruments will be alone in their extensive research.

The 1350 kg CRISTA instrument dominates the ASTRO-SPAS satellite in terms of size at least, since it amounts to a huge 1.3 m diameter telescope with a length of 2.9 m. Its area of interest is the so-called 'middle atmosphere', in particular the region between the altitudes of 10-100 km above the surface. CRISTA's infrared sensors will pay close attention to small and medium-sized dynamic structures, such as waves and air turbulence, which are at present inaccessible to other Earth-observation satellites. Also, since no measurements have been made on the occurrence frequency of these structures, CRISTA's observations will provide the first accurate glimpse of global distribution and frequency levels.

To fulfil its complex objectives, CRISTA is equipped with three independent telescopes, which will be trained on the limb of the Earth's atmosphere in middle and far-infrared wavelengths to monitor the emission and distribution of certain gases. These will be used as tracers to identify the small and medium dynamic structures, although CRISTA will probably also be focused on large-scale structures if these also appear during its measurements. All three telescopes are equipped with a middle-infrared spectrometer, and the centre telescope also carries a far-infrared spectrometer; together, these will be capable of simultaneously measuring ten different trace gases. In order to achieve a sufficient level of sensitivity for these observations, all parts of the telescope optics must be cooled to cryogenic temperatures by means of liquid helium.

Supplementing CRISTA will be the smaller MAHRSI instrument, whose main objective is to create density profiles for hydroxyl and nitric acid, both of which play major roles in the destruction of ozone. The observations of MAHRSI will cover the altitude range between 40 and 150 km above the surface, measuring the brightness of the Earth's 'dayglow' and also, by monitoring backscattered sunlight from the atmosphere, providing further details on the density and temperature of the mesosphere region.

The CRISTA/MAHRSI mission, to be repeated in November 1996 if its debut is successful, marks the latest member of the Shuttle-carried Mission to Planet Earth programme and joins its contemporaries - SSBUV, ATLAS, SRL and LITE - in an attempt to understand more about the fundamental workings of the Earth's atmosphere. ■

Previous Missions with SPAS and ASTRO-SPAS

On its first operational flight, designated SPAS-II, the free-flyer was required to withdraw to a distance of several kilometres from the Shuttle in order to monitor at infrared wavelengths the thruster-plumes from the Reaction Control System (RCS) steering jets, the limb of the Earth's atmosphere, the environment around the orbiter, and chemical releases from canisters mounted in the open payload bay. The primary instrument on SPAS-II, known as the Infrared Background Signature Survey (IBSS), is scheduled to be re-flown on a May 1996 Shuttle mission carrying the designation of SPAS-III.

The ASTRO-SPAS programme was approved between NASA and the German Space Agency (DARA GmbH), who agreed to fly at least four joint missions of the system, which would consist of two carrying the CRISTA/MAHRSI instruments and two others carrying the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer (ORFEUS) astronomy telescope.

The first ASTRO-SPAS instrument to fly was ORFEUS, which was carried into orbit by the Space Shuttle Discovery on mission STS-51 in September 1993 and successfully spent six days in free-flight prior to its retrieval and return to Earth. The facilities offered by ASTRO-SPAS were demonstrated to great effect, and the pathfinding mission cleared the way for the maiden flight of CRISTA/MAHRSI a year later.

A fifth mission, known as the Automated Rendezvous and Capture Experiment, has been proposed by the European Space Agency (ESA) and would envisage the release of a small subsatellite from ASTRO-SPAS. The two craft would then move away from each other, after which the subsatellite would attempt a rendezvous and re-docking manoeuvre as part of demonstrations into the feasibility of automated-rendezvous and proximity operations. The proposal remains at the planning stage, however, and has yet to receive funding.

Gagarin and Khrushchev in Red Square. In the early 1960s, decisions often depended on the personal views of Khrushchev.

Part 2 - Organisational Structure in the 1960s

In the 1950s, the management of the entire defence industry and thus the early space programmes of the USSR was performed by a very powerful body named the Military-Industrial Commission (VPK), which essentially coordinated and controlled all defence-related research, design, development, testing and production activities. The VPK maintained direct contact with the Party structure (i.e. with the real power).

During this period, Khrushchev and Brezhnev determined the actual course of the space programme.

BY ASIF A. SIDDIQI
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Government: Early 1960s

In the early days of the space programme, following the first Vostok mission in 1961, the Chairman of the State Commission became Leonid V. Smirnov who was also concurrently named Chairman of the GKOT (the State Committee for Defence Technology). The sharing of the two positions by the same individual indicated not only the importance that Khrushchev saw in the space programme, but also hinted at the defence-related nature of much of the space programme's administration.

The same year, an official decree was passed defining the rights and status of the Council of Chief Designers [1]. It appears that Korolev was beginning to have problems with the appropriate Ministries and Committees concerning the jurisdiction and influence of the Council. The new resolution secured the decisions of the Council as binding for all Ministries and Committees [2].

During Khrushchev's reign, the power of the Council was so strong that it often bypassed the regular hierarchy of the 7th Chief Directorate, the GKOT, the VPK, the Secretariat, the Politburo, finally going to Khrushchev himself. Despite the unofficial channels of leadership, the Council could not be assured of approval of any proposals, and often decisions depended on the personal views of Khrushchev.

During the latter years of the Khrushchev era, Ustinov's personal role in determining space and rocketry policy appears to have diminished. He was relieved of his duties as Chairman of the VPK in March 1963 and replaced by Smirnov. Smirnov's position as Chairman of the State Commission was taken by Maj.-Gen. Georgy A. Tyulin in late 1962.

By the early 1960s, besides the six primary Design Bureaus (KBs) whose heads were members of the Council of Chief Designers, at least four other KBs were assuming very prominent roles in the space programme:

1. Established in 1952, the SKB-586 had been headed since 1954 by Chief Designer Mikhail K. Yangel, a former employee of Korolev's. Based at Dnepropetrovsk, Yangel was deeply involved in the development of strategic missiles and military satellites for the Ministry of Defence;
2. Chief Designer Vladimir N. Chelomei had headed the OKB-52 since 1959 working under the Ministry of Aviation Industry. By the early 1960s, he had begun research work on space-related projects including a series of new launch vehicles and piloted spacecraft;
3. Since its inception in October 1951, Chief Designer Semyon A. Kosberg had headed a KB focused towards the design of upper stage rocket engines for satellite launch vehicles; and
4. Alexei M. Isayev, an associate of Korolev's and Chief Designer of a KB since about 1944 had by the late 1950s begun design and construction of engines for spacecraft in his own SKB-2.

Although not part of the core Council of Chief Designers, these four individuals played key roles in both the R&D and implementation stages of many space projects at the time.

Party: Early 1960s

Leonid I. Brezhnev was the top Party official in the space programme until 1960 at which point, his duties were transferred to other areas. It appears that most of his responsibilities in the defense sector may have been delegated to Frol R. Kozlov who was Secretary of the Central Committee of the KPSS until 1963. As part of a reshuffling of positions in March 1963, Brezhnev was re-appointed to his earlier position, thus resuming his earlier role as *de facto* head of the space and missile programmes. Brezhnev remained at that position until at least October 1964 when there was a change in the Soviet leadership.

Government: Mid 1960s

Following the ascension of Leonid I. Brezhnev and Alexei N. Kosygin to power in the USSR in October 1964, there was a thorough review of the administration of the space programme. This partly stemmed from the need of a complete re-organisation due to the increasingly growing nature of the Soviet space programme. Following this review, on March 2 1965, the 7th Chief Directorate within the GKOT was completely reorganised, given a wider jurisdiction and renamed the USSR Ministry of General Machine Building (MOM) [3,4].

The MOM was given direct control of almost all of the USSR's missile and space industry (see Organisation Chart overleaf). Sergey A. Afanasyev,

a member of the Central Committee of the KPSS, was named the first Minister of the organisation. Former State Commission Chairman Smirnov who had been Chairman of the VPK since 1963 retained his position as direct superior to Afanasyev.

Since the VPK's key role was in the authorisation of budgets for all military programmes, including the MOM, Smirnov exercised a great influence over programme starts and continued funding of current space programmes. The VPK appears to have been an accessory body to the Council of Ministers, Smirnov reporting directly to the Prime Minister of the Soviet Union.

The newly created MOM was given four Main Production Associations (GPUs):

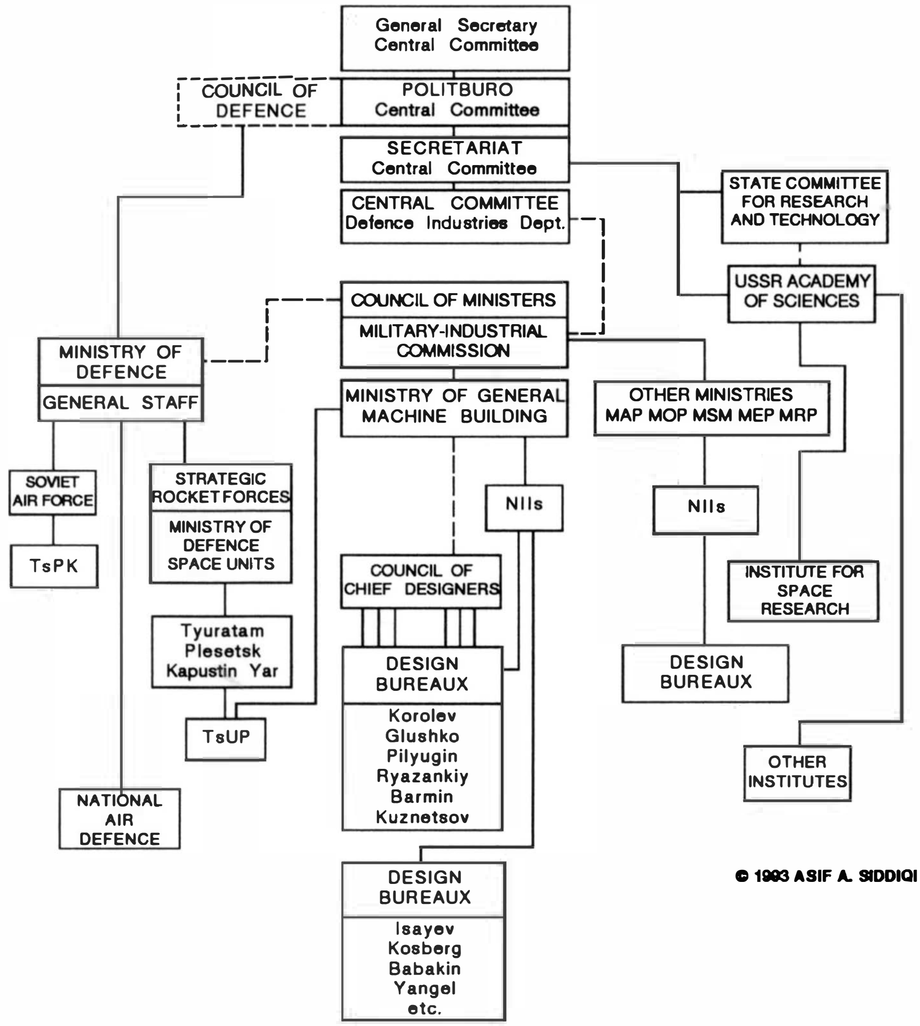
1. Strategic missiles and space vehicles;
2. Propulsion;
3. Guidance; and
4. Ground support equipment [4].

Directly below the MOM were almost all of the Design Bureaus (KBs) and Scientific Research Institutes (NIIs) involved in the space programme, such as those headed by Korolyev, Glushko, Barmin, Isayev, Kosberg, Yangel, etc. It seems that the OKB-52 headed by Chelomei which had been under the jurisdiction of the Ministry of Aircraft Production (MAP), was brought into the MOM at that time. The former NII-88, to which the OKB-1 had been responsible, was reorganised and renamed the Central Research Institute for Machine Building (TsNIIMash) and absorbed by the MOM in 1965 [5].

The new TsNIIMash still maintained its staff and extensive facilities and had the critical responsibility for recommending contractors for new projects that were to be approved by the MOM. With the new organisation, the MOM later approved new ministry names for the KBs: the OKB-1 headed by Korolev was named the Central Design Bureau of Experimental Machine Building (TsKBEM) while the OKB-52 headed by Chelomei was named the Central Design Bureau of Machine Building (TsKBM).

The MOM was also given the responsibility of recommending new candidates for the heads of important KBs to the Council of Ministers. One of the first uses of this authority was the appointment of Vasili P. Mishin as head of the OKB-1 in January 1966 following the death of Korolev.

While the MOM was given the responsibility of administering the entire Soviet space programme, its jurisdiction was often limited to production and project direction. For example, once the MOM had developed ground infrastructure for a particular project, operational control was handed over to the General Directorate for Space



Organisation of the Soviet Space Programme post-1965.

Systems (UNKS), unofficially called the Space Units of the Strategic Rocket Forces.

Although active in the launch of all Soviet rockets since the late 1940s, the UNKS was organised in 1966 or 1968 [6] as a formal unit of the Strategic Rocket Forces. The facilities under UNKS control included the three launch centres, the ground segment of all Soviet space systems, except piloted craft and meteorological and scientific satellites. The UNKS were responsible for the launch preparations of every single satellite in the Soviet space programme. The MOM did, however, have control over the Flight Control Centre (TsUP) from which all piloted missions were directed, although some reports suggest that even control of the TsUP was shared with the Space Units [7].

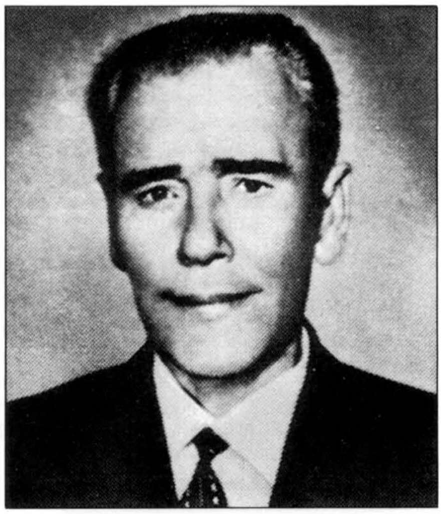
Early warning and some surveillance satellites were under the control of the Air Defence Forces (PVO) another branch of the Ministry of Defence while all reconnaissance satellites were under the jurisdiction of the Ministry of Defence General Staff's Chief Intelligence Directorate (GRU) and the Navy Staff's Intelligence Directorate [5]. The key influence of the Soviet Air Force (VVS) continued through the control and administration of the Training Centre for Preparing Cosmonauts (TsPK) near Moscow. The VVS thus had significant influence over the selection of cosmonauts and crews.

Party: Mid 1960s

Following the fall of Khrushchev, Dmitry F. Ustinov was made not only a Candidate Member of the all-powerful Presidium in 1965, but also Secretary of the Central Committee Secretariat specialising in the defence industry. After twenty years in the defence industry, Ustinov was finally inducted into the top levels of the Party structure. He served as the liaison between Smirnov and Afanasyev to Brezhnev, the General Secretary of the CPSU.

Following the deposement of Khrushchev, Brezhnev delegated much of the authority of the space programme to Ustinov. This was a significant change from the Khrushchev years, when Khrushchev himself took a personal interest in the space programme.

One other individual who also played a critical role in the space administration was Ivan D. Serbin, the head of the Defence Industries Department of the Central Committee since 1958. Note that Ustinov supervised the defence matters as a member of the Central Committee Secre-



Left: Valentin Glushko, who believed that hydrogen and oxygen were not the best propellant combination. Centre: Vladimir Chelomei, who led the design of large boosters, such as the Proton and was general designer of the Salyut Programme. Right: Mikhail Yangel, who developed strategic missiles and military satellites.

tariat while Serbin was head only of a Central Committee department; Ustinov obviously exercised control over Serbin, being at the apex of the Party hierarchy. It appears that beginning in the mid-1960s, Ustinov was the *de facto* head of the Soviet space programme. He remained at this position until 1976.

Hierarchy: 1960s

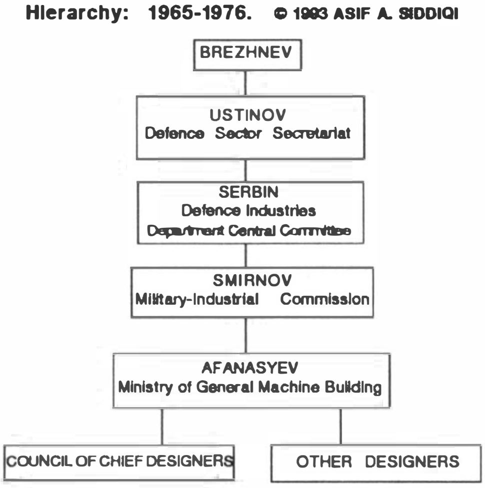
It seems that the Council of Chief Designers lost much of its direct line to the Kremlin following the organisation of the MOM and in particular the death of Korolev in 1966. Still, it remained a fairly powerful and influential body since many of the most significant projects in the Soviet space programme originated from the Council in the form of "resolutions" that were usually passed unanimously. These resolutions would then be reviewed by a special commission of the Academy of Sciences (AN-SSSR) usually headed by President Mstislav V. Keldysh who continued to have influence over project design.

In some cases, it appears that the AN-SSSR would review Council proposals and modify them to fit certain requirements of the space programme. Additional input would be received from the State Committee for Research and Technology (GKNT), the top governmental body for the administration of Soviet science. The approved proposal would then be passed on to the TsNIIMash branch of the MOM which would include it as part of its annual space plan. The plan would then be reviewed by a "collegium" of MOM officials directed by Minister Afanasyev. Often delegates from other Ministries and the AN-SSSR would be involved at this stage of the proposal [5].

The MOM would then pass its budget request to the VPK around May of the following year; the VPK would determine the eventual fate of the proposal. Often, officials at the VPK itself would restructure the request along the line of its own policy. Following approval by the VPK, the proposal would be signed into law by the President of the USSR [5].

The role of the State Commission remained more focused towards the facilitation of programmes rather than any policy determination. The Commission was headed by Lt. Gen. Kerim A. Kerimov from 1965, but it seems that he did not concurrently hold the post of Chairman of the GKOT as his predecessors did. Thus his overall administrative powers were relatively diminished. This was surely in part due to the formation of the MOM in 1965 and the appointment of Afanasyev. Kerimov did, however, continue to maintain final control of launches, crew selection, launch preparations and flight manifests, certainly key areas of the space programme.

Hierarchy: 1965-1976. © 1993 ASIF A. SIDDIQI



Selected sources for above chart:
1. Maxim Tarasenko, *Military Aspects of Soviet Cosmonautics*, Agentsvo Rossiskoy, Moscow, 1992, p.19.
2. Hariet Fast Scott and William F. Scott, *The Armed Forces of the USSR*, Westview Press, Boulder, 1979.
3. Directorate of Intelligence, *The Soviet Weapons Industry: An Overview*, Central Intelligence Agency DI 86-10016, September 1986.
4. Jiri Valenta and William C. Potter, eds., *Soviet Decision making for National Security*, George Allen & Unwin, London, 1983.

This was, of course, the official hierarchy of the administration, but political manoeuvring often distorted or circumvented the established chain-of-command. During Korolev's lifetime, in particular, the unusual nature of the personal relationships between Korolev, Chelomei, Glushko, Yangel and the Soviet leaders played a larger role than any official budget approval process. Often the Soviet government would issue a "resolution" for a particular objective in the space programme, and the different KBs would vie for ultimate selection for the programme, much like the competition of prime contractors in the United States. In particular, three of the most powerful KBs, those headed by Korolev, Chelomei and Yangel competed against each other for ultimate approval by both the AN-SSSR and the TsNIIMash. The final selection was often a result of political manoeuvring and a function of the climate of relationships with Afanasyev, Smirnov or Ustinov. In particular, it should be noted that the Defence Department of the KPSS Central Committee had a significant influence over the approval process. The VPK and the MOM rarely, if ever, failed to approve rulings originating in the Defence Industries Department [5]. Following final selection, the government would issue a timetable for the completion of the project. The Council of Chief Designers in association with the State Commission would then attempt to meet the schedule in co-ordination with the resources of the MOM.

One example of this sequence was the aborted piloted lunar landing programme: the government issued a resolution in August 1964 calling for such a project; three KBs (Korolev, Chelomei and Yangel) then vied for final approval; a commission from the AN-SSSR reviewed the proposals and approved further work for the Korolev proposal in November 1966; finally the

Soviet government issued a decree in February 1967 with a specific timetable. It must be emphasised that each space project had its own anomalies in the process to approval, and the lunar project is just one example of how the process was enacted.

This weblike organisational structure was maintained unchanged almost through to the late-1980s. Despite changes in the personalities in the space programme, the essential nature of the administrative structure of the space programme would not be changed until the dissolution of the Soviet Union at the end of 1991. It has been argued that the existence of a centralised agency would have hastened the progress of the Soviet space programme, but the evidence shows that despite the overtly bureaucratic structure of the programme, the Soviets were still the foremost spacefaring nation in the late 1950s and early 1960s.

References

1. B. Konovalov, "Dash to the Stars," *Izvestiya*, October 1 1987, p.3.
2. B. Konovalov, "Lessons of the First Satellite," *Izvestiya*, Sept 29 1987, p.3.
3. Yu. Mozzhorin and A. Yeremenko, "From the History of Space Science: From the First Ballistics to....," *Aviatsiya I Kosmonavtika* 8:34-35 (1991).
4. Steven Zaloga, "Soviet strategic missile development and production," *Jane's Defence Weekly*, May 30 1987, pp.1061-1064.
5. Stephane Chenard, "Twilight of the machine builders," *Space Markets* 5:11-19 (1991).
6. Stephane Chenard, *Space Directory of Russia*, Euroconsult, Paris, 1993, p.166.
7. Maxim Tarasenko, *Military Aspects of Soviet Cosmonautics*, Agentsvo Rossiskoy, Moscow, 1992, p.19.

Table 1: Administrative Organisations in Missile and Space Programmes

POLICY

Special Commission No. 2:
Established April 1947
Oversaw strategic missile programmes policy until the late 1950s:
Chairmen:

I.A. Serov:	47-47
G.M. Malenkov:	47-51
V.M. Ryabikov	51-55

KPSS Secretariat:
Highest individuals in the USSR responsible for defence and space programme policy:

L.I. Brezhnev:	56-60
F.R. Kozlov:	60-63
L.I. Brezhnev:	63-65
D.F. Ustinov:	65-76
Y.P. Ryabov:	76-79
none	79-83
G.V. Romanov:	83-85
L.N. Zaikov:	85-88
O.S. Baklanov:	88-91

Central Committee Defence Industries Department:
Second level of individuals responsible for defence and space programmes:

I.D. Serbin:	58-81
I.F. Dmitriyev:	81-85
O.S. Belyakov:	85-90

IMPLEMENTATION

Military Industrial Commission (VPK):
Established January 1938
Top body responsible for ensuring fulfilment by Ministries of policies for space and defence-related production:
Chairmen:

V.D. Malyshev:	53-55
M.V. Khrunichev?:	55-56
D.F. Ustinov:	57-63
L.V. Smirnov:	63-85
Y.D. Maslyukov:	85-88
B.S. Belousev:	86-91
Y.D. Maslyukov	91-91

Ministry of Defence Industries:
Established 1946 and named
Ministry of Armaments 1946-1953
Governmental supervision over development and production of artillery and strategic missiles in the period 1946 to 1957:
Minister:

D.F. Ustinov:	46-57

First Deputy Ministers:

V.M. Ryabikov:	46-51
K.N. Rudnev:	52-57

State Committee for Defence Technology (GKOT):
Established January 1958
Governmental supervision over development and production of artillery and strategic missiles in the period 1958 to 1965:
Chairmen:

A.V. Domrachev	58-58
K.D. Rudnev:	58-61
L.V. Smirnov:	61-63
S.A. Zverev	63-65

7th Chief Directorate:
Established 1946
Governmental direction of research, development and manufacture of strategic missiles and space vehicles in the period 1946 to 1965:
Chairmen:

S. Vetoshkin:	46-??

Ministry of General Machine Building (MOM):
Established March 1965
Governmental direction of research, development and manufacture of strategic missiles and space vehicles in the period 1965 to 1991:
Ministers:

S.A. Afanasyev:	65-83
O.D. Baklanov:	83-88
V. Doguziev:	88-89
O.N. Shishkin:	89-91
R.R. Kiryushin:	91-91

State Commission:
Established 1958
Supervision and approval of launches, crews, manifests, mission events in space programme:
Chairmen:

K.N. Rudnev:	58-61
L.V. Smirnov:	61-62
G.A. Tyulin:	62-65
K.A. Kerimov:	65-91

CLIENTS

Ministry of Defence:
Ministers:

G.K. Zhukov:	53-57
R.Y. Malinovsky:	57-67
A.A. Grechko:	67-76
D.F. Ustinov:	76-84
S.L. Sokolov	84-87
D.T. Yazov:	87-91
Y.I. Shaposhnikov	91-91

Strategic Rocket Forces (RVSN):
Established December 1959
Commanders-in-Chief:

M.I. Nedelin:	59-60
K.S. Moskalenko:	60-62
S.S. Biryuzov:	62-63
N.I. Krylov:	63-72
V.F. Tolubko:	72-85
Y.P. Maksimov:	85-91

RELATED ORGANIZATIONS

Ministry of Medium Machine Building (MSM):
Established June 1953 and named
1st Chief Directorate from 1946-1953
Governmental direction of research, development and procurement of nuclear weapons:
Ministers:

V.A. Malyshev:	53-55
A.P. Zavenyagin:	55-56
M.G. Pervukhin:	56-57
Y.P. Slavskiy:	57-86
L.D. Ryabev:	86-89

Soviet Air Force (VVS):
Commanders-in-Chief:

K.A. Vershinin:	46-49
P.F. Zhigarev:	49-57
K.A. Vershinin:	57-69
P.S. Kutakhov:	69-85
A.N. Yefimov:	85-88
Y.I. Shaposhnikov:	86-91

SCIENCE SECTOR

State Committee for Coordination of Scientific Work (GKNT):
Established 1961 and named
State Committee on Science and Technology from 1965
Primary governmental supervision over scientific research and development:
Chairmen:

M.V. Khrunichev:	61-61
K.N. Rudnev:	61-65
V.A. Kirillin:	65-80
G.I. Marchuk	80-86
B.L. Tolstykh:	87-91

USSR Academy of Sciences (AN-SSSR):
Direction and monitoring of scientific research and development:
Presidents:

A.N. Nesmeyanov:	-61
M.V. Keldsyh:	61-75
A.P. Alexandrov:	75-86
V.A. Kotelnikov:	86-86
G.I. Marchuk:	86-

Selected Sources

1. Scott, Harriet Fast and William F. Scott, *The Armed Forces of the USSR*, Westview Press, Boulder, 1979.
2. Mozzhorin,Yu. and Y. Yeremenko, "From the History of the Space Sciences: From the First Ballistics to...", *Aviatsiya I Kosmonavtika* 7(1991), pp.40-41.
3. Mozzhorin,Yu. and Y. Yeremenko, "From the History of the Space Sciences: From the First Ballistics to..", *Aviatsiya I Kosmonavtika* 8(1991), pp.34-35.
4. Cooper, Julian, "The Elite of the Defence Industry Complex" in Lane, David, Ed., *Elites and Political Power in the USSR*, Edward Elgar, London, 1988, pp.167-187.

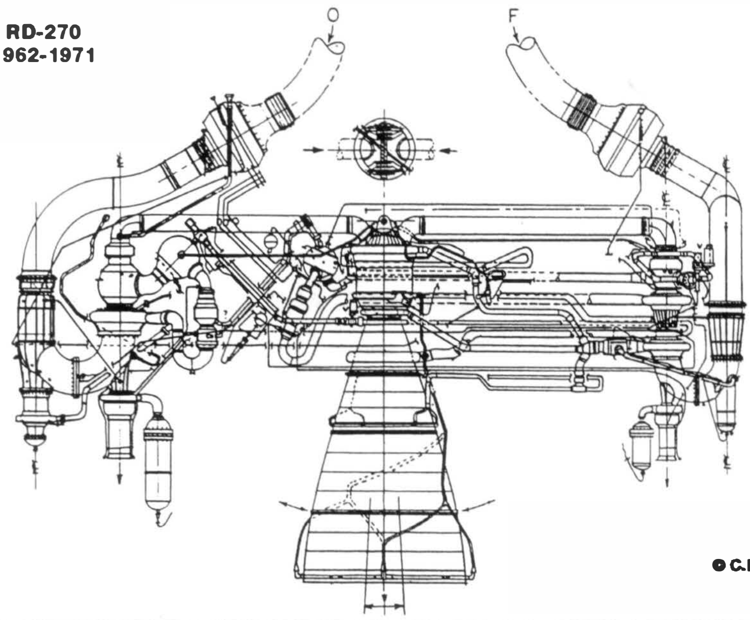
Energomash Reveals 'F-1 Class' Rocket Engine

Energomash has revealed that it was the former Gas Dynamics Laboratory Design Bureau led by the late General Designer V.P. Glushko that successfully developed the RD-270, an F-1 class engine, for the V.N. Chelomei Design Bureau (now renamed State Space and Rocket Centre).

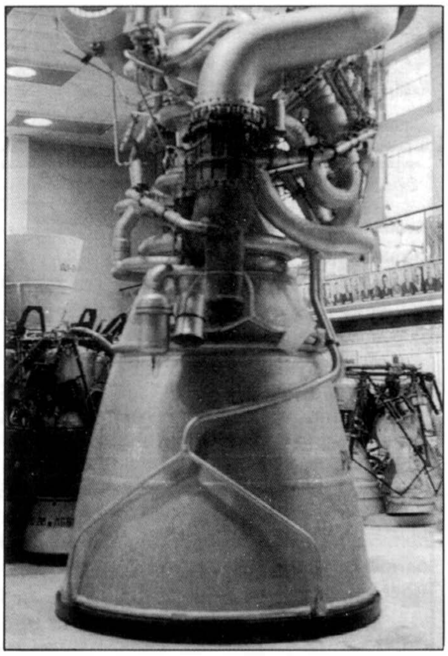
Developed between 1962 and 1971 the RD-270 engine was designed for the competing manned Moon boosters, the UR-700 and the R-56 and for the UR-700M Mars booster concept. UR-700M was planned to carry out a manned Mars circumnavigation mission and eventually a manned Mars landing.

Toxic propellants, UDMH fuel with nitrogen tetroxide as its oxidiser, were utilised in a single large thrust chamber engine. It produced a sea-level thrust of 640 tonnes (6,272 kN) and a vacuum thrust of 685 tonnes (6,713 kN) with a fuel to oxidiser ratio of 2.67. The RD-270 operated with a sea-level specific impulse of 301 seconds and a vacuum specific impulse of 322 seconds. Its combustion chamber pressure is 266 atm and it had a nozzle exist pressure of 0.86 atm. The mass of the 4.850 m tall engine dry is 4,770 kg and with fuel is 5,603 kg. The nozzle's exit diameter is 3.300 m. The accompanying schematic diagram of the RD-270 shows that the gimbal-mounted closed cycle engine can be rotated in one plane through several degrees. It also features two separate turbopump assemblies and two solid charge motor starters.

RD-270
1962-1971



© C.P. VICK 1992/3



RD-270, NPO Energomash Museum [1].
DIETRICH HAESELER

Until recently it was assumed that the Russians had not mastered the technology for high thrust rocket engines with single large thrust chambers. Along with the known static test-stand capability of 1.74 million pounds thrust that pre-dates RD-170/171, this myth can safely be put to rest.

© CHARLES P. VICK, 1993

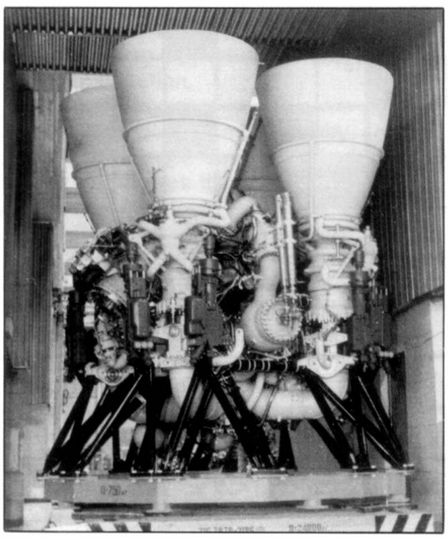
Reference

1. D. Haeseler, "Soviet Rocket Motors on View", *Spaceflight*, 35, p.40 (1993).

Soviet Rocket Engine Available in US

The RD-170 is now available for applications in the United States through an agreement between Pratt & Whitney and NPO Energomash. Development of the engine was initiated in the mid 1970s with the first flight occurring in 1985. The quality control system and specifications were developed from US requirements. The engine is more than 10% higher in performance than other existing lox/kerosene booster engines and has a fully developed, operational, advanced health monitoring/life prediction system. It was designed to provide a minimum of 10 reuses before overhaul and enable between flight servicing and initial flight preparation with automated operations. Its operability is a major contributor to the less than seven-day launch timeline of the Zenit launch system.

The four-chamber modular configuration RD-170 rocket engine.
PRATT & WHITNEY/NPO ENERGOMASH

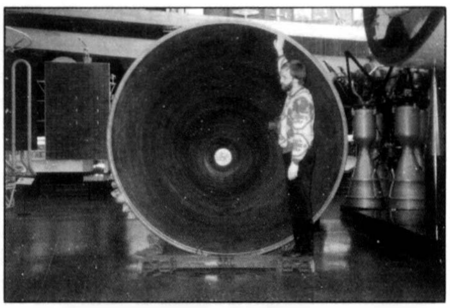


General Description

- Operational certification 1985
- 200+ engines produced
- >100,000 sec and > 900 firings
- 27 flight firings (December 1992)
  19 Zenit 8 Energiya
- Qualified for 10 mission reusability
- Fully developed health monitoring/life prediction system

Characteristics of RD-170

• Nominal thrust (SL)	1,632,000 lb
(Vacuum)	1,777,000 lb
• Specific impulse (SL)	309 sec
(Vacuum)	337 sec
• Chamber pressure	3,560 psia
• Nozzle area ratio	36.4:1
• Mixture ratio	2.6
• Length	157.5 inches
• Diameter (inches)	148.8 frame/ 145.7 nozzles
• Throttle range	40-105%
• Total dry weight	26,575 lbs



Nozzle exit of the RDO-120 engine used in the Energiya Central Core (4 x RDO-120) seen at the Tsiolkovsky Museum Kaluga.

SATELLITE DIGEST-268

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Cosmos 2281	1994-032A	Jun 7.31	Plesetsk	Soyuz	6,300 ?	Jun 10.10	82.58	89.84	237	296	[1]
Foton 6	1994-033A	Jun 14.67	Plesetsk	Soyuz	6,200 ?	Jun 14.85	62.81	90.36	221	364	[2]
INTELSAT 702	1994-034A	Jun 17.27	Kourou	Ariane 44LP	3,695	Jun 21.72	1.00	1,091.16	21,712	35,750	[3]
STRV 1A	1994-034B				50	Jun 17.97	7.04	633.57	282	35,822	[4]
STRV 1B	1994-034C				53	Jun 17.97	7.04	634.89	284	35,899	[4]
UFO 3	1994-035A	Jun 24.58	ER	Atlas-1	2,847	No orbital data released					[5]
STEP 1	None	Jun 27.89	WR	L-1011/ Pegasus	348	Failed to reach orbit					[6]

NOTES

1. Rare third generation photoreconnaissance satellite in the Zenit series: recovered aproximately June 29.1
2. Ninth Foton microgravity research/materials processing satellite to be launched. The first three flights were within the Cosmos programme, and the previous named Foton missions have been identified as Fotons 1-5: however, the launch announcement identified the new launch as "Foton 9" rather than the correct sequential "Foton 6" used here. Carried equipment for the production of semi-conductors, glasses and biological active substances in microgravity, in addition to experiments for ESA, France and the German Biopan commercial package. Recovered July 2.23.
3. Second launch of new-generation INTELSAT-7 series satellite. Mass quoted above is at launch: on station the mass should be 2,250 kg and at the end of the satellite's lifetime it will have dropped to 1,495 kg. Planned for location over 359 °E.
4. STRV 1A and 1B (Space Technology and Research Vehicle) are two small sub-satellites launched for the UK Ministry of Defence for technology demonstrations and various scientific investigations.
5. Third UHF Follow-On satellite, also called USA 104. Spacecraft is part of the programme to replace Fltsatcom defence communications payloads. Mass quoted above includes propellant: after reaching geosynchronous orbit the mass was approximately 1,280 kg. Unlike the two previous launches (UFO 1, 1993-015A and UFO 2, 1993-056A) no orbital data were issued for the satellite.
6. STEP 1 (Space Test Experiment Program) payload was the third to be launched, following STEP 0 (1994-017A) and STEP 2 (1994-029A). First use of Orbital Sciences Corp L-1011 Stargazer aircraft to carry Pegasus to altitude and first use of Pegasus XL variant. After departing Vandenberg Air Force Base, the Pegasus was deployed. Pegasus was self-destructed 2 minutes 53 seconds after deployment. There were some reports of debris coming from Pegasus about 40 seconds after launch followed later by a loss of telemetry.

ADDITIONS AND UPDATES

1963-024A TIROS 7 decayed from orbit 1994 June 3.

1988-091B TDRS 3 was manoeuvred off-station over 298 °E 1994 May 16: the satellite was still drifting to the west at the end of June.

1994-002A During 1994 June 12-13 the orbit of Gals 1 was stabilised over 70 °E.

1994-031A Progress-M 23 undocked from the Mir Complex 1994 July 2.37 (08.47 GMT) and was de-orbited later the same day.

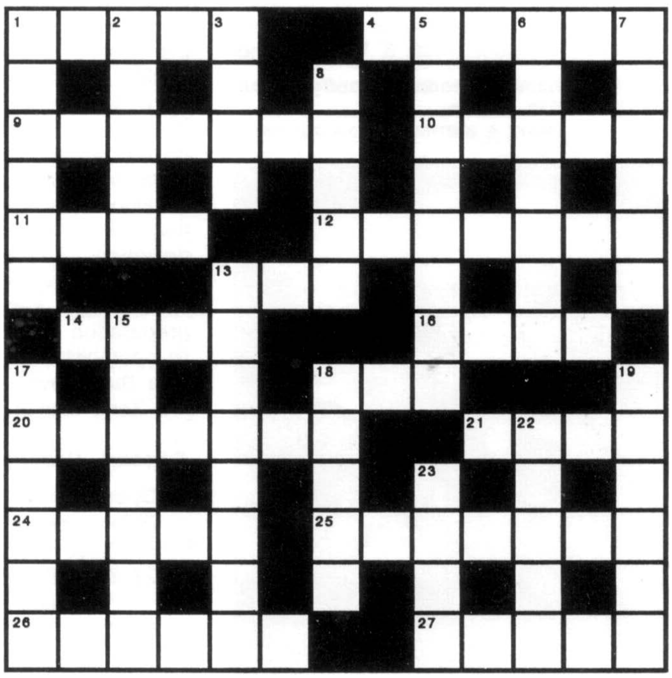
Spaceflight Crossword

No. 13

ACROSS
1+4. Sun and its attendant bodies (5,6)
4. See 1 Across
9. Violent wind storm
10. Top
11. Reddish-brown coating on iron
12. Propulsion devices
13. Forepart of ship
14. Propels Space Shuttle (acronym)
16. Locate
18. Target for mission STS-61 (acronym)
20. Get
21. Earth observation satellite
24. Extraterrestrial, may be
25. In the constellation of the Sail
26. Holding
27. Computer language

DOWN
1. Planet
2. Sources of light
3. Spool for a Highland dance ?
5. Least in age
6. Tuft of hair
7. Marsh
8. Scatter loosely
13. Novice
15. Negative pressure
17. Wandering
18. Of high specific gravity
19. Form of power
22. European capital
23. Roundish drop

Solution will appear in the October issue.



Solution to Crossword No.12.
ACROSS: 1. Taurus; 4. Insert; 7. Patrol car; 9. Veer; 10. Rose; 11. Cubic; 13. Leaves; 14. Delays; 15. Cycles; 17. String; 19. Salts; 20. Ride; 22. Info; 28. Explorers; 24. Elated; 25. Dented.
DOWN: 1. Travel; 2. Roar; 3. Sirius; 4. Inlaid; 5. Star; 6. Timers; 7. Penal code; 8. Rotations; 11. Ceres; 12. Cents; 15. Chrome; 16. Sailed; 17. Stored; 18. Ground; 21 Exit; 22. Iron.

Moon Shot: The Inside Story of America's Race to the Moon

A. Shepard and D. Slayton, Virgin Publishing Ltd, 332 Ladbroke Grove, London, W10 5AH, 1994, 383pp, £15.99, ISBN 1-85227-498-0.

On July 20th 1969, eight years after President Kennedy promised that the Americans would land a man on the Moon, the crew of Apollo 11 touched down on the Sea of Tranquillity.

This book is the story of the courage, dedication and teamwork which lay behind this epic feat and which made the Apollo 11 journey possible.

As both authors were members of the original Mercury Seven Team they were intimately involved in the pioneering space programme from the beginning, both as astronauts and as key members of the NASA Astronaut Office, so they are perfectly placed to tell the inside story.

This account describes not only days of discovery and achievement but also some of the bitter disappointment, even tragedy, that wracked the world of those blazing a trail into the unknown.

How we got to the Moon: The Story of the German Space Pioneers

M. Freeman, 21st Century, PO Box 16285, Washington DC 20041, USA, 1994, 385pp, $15.00, ISBN 0-9628134-1-9.

This book describes how the several hundred German and German-born American space pioneers contributed to the US Space Programme to reach the Moon.

It is extensively researched, very readable and, undoubtedly, an excellent book for those wishing to learn about the early days and the origins of the space programme, beginning with the backyard experiments of the 1920s and early 1930s up to the Apollo 11 launch in 1969, and not forgetting the criticisms and arguments made against space flight by opponents of the idea.

The story begins with the pioneering theoretical work of Hermann Oberth and continues through the development of the German V2 (A4) rocket up to Operation Paperclip, whereby substantial numbers of leading German space engineers were transferred to America to lay the foundation for the American Space Programme.

Particularly interesting is the work of Willy Ley, Wernher von Braun and Kraft Ehricke, all former Fellows of the Society, who provided continuing vision and initiatives up to the time of their deaths.

Space Systems - Design and Technology

Daniel Marty, Department Head at CNES, Masson, 120 Boulevard Saint-Germain 75280, Paris, France, (French text apart from a short Forward and an Index in English), 1994, 352pp, 230 illustrations "Soft" Cover 297 FF.

This book surveys the history and various elements of space technology. It discusses the fundamental problems that required solving during the development phase of this technology and ends with current applications and future possibilities.

The book is divided into three major sections, each comprising several chapters.

The first is devoted to space trajectories and orbits (Earth and interplanetary); re-entry vehicles (aerodynamics and thermodynamics of ballistic and winged configurations); and launching vehicles.

The second covers launching systems in general, including launcher requirements and development.

The final section deals with satellite development (project management and organisational aspects) satellite technology, ground support equipment and space applications.

The book covers an extremely wide range and is profusely illustrated with photographs, tables, mathematical illustrations and graphs.

A sound mathematical knowledge is required to appreciate fully how the various problems associated with orbital mechanics, interplanetary orbits, re-entry aspects, structural concepts, thermal control systems etc. were tackled. However, even without this, the book still provides a comprehensive record of space achievements over many decades.

Understandably, while space activity in the many countries involved is recorded, a significant proportion of the technology discussed concerns the French space programme, particularly development of the Ariane vehicle.

The space history is reasonably up to date for a 1994 publication date, apart from recent new initiatives from ESA e.g. the new European Manned Space Transportation Programme in which the role of Hermes will be reoriented.

Space Almanac

A.R. Curtis, Gulf Publishing Company, Distributed by Plymbridge Distributors Ltd., Plymouth, PL6 7PZ, 1994, 746pp, Paperback £21.99, Hardback £30.99, ISBN 0-88415-039-9.

This handy database-in-a-book covers just about everything one may wish to know about space exploration. It features Space Shuttles, Stations, Rockets and Satellites, Astronauts and Cosmonauts, the Solar System and Objects found in Deep Space.

It also includes comprehensive listings of the space activities of America and the former USSR, besides those of Germany, Japan, China, India, Israel, Brazil and the European Space Agency.

A number of very useful appendices conclude the book.

COMPUTER SOFTWARE

Satellite Databases

Space 2000: a satellite database for IBM PCs and compatibles, published by Space Analysis and Research Inc., PO Box 49466, Colorado Springs, Colorado, 80949-9446 USA. Tel 0101-719-260-0500. ISSN 1064-2064. System Requirements: 512 Kbytes RAM, 3.5 Mbytes hard disc space. Supplied on 5.25" floppy discs. MSDOS 3.0 or higher. Printer optional. Price outside USA (in US $ excluding postage): $285.00 with updates over one year. Subsequent quarterly updates: $90.00 per year.

Quick Search: a shareware satellite database for IBM PCs and compatibles, also published by space Analysis and Research Inc. System Requirements; as Space 2000 but needs only 700 Kbytes hard disc space. Prices outside USA (in US $ excluding postage): Registration cost: $25.00; quarterly upgrades available to registered users at $16 each.

Space 2000 is a database of over 5,000 launches and their payloads covering the period from 1926 to the present day and including predictions for launches to the next century. It provides the user with over twenty keys on which to compose searches, including searching by name, type, launcher, launch site, orbital details, date or period of interest, nationality and astronaut names. Keys can be used in combination for more precise searches and wildcards can be used when some of the search details are uncertain. Space 2000 will even hazard a guess at the mission type from limited launch details such as may be available from published material on CIS launches. The information extracted from the searches is tabulated using preset formats and may be sent to the screen or an optional printer. There is on-line help covering a wide variety of astronomical, database and operating topics and the program also comes with a thirty page user manual.

Information for the database comes from a variety of recognised sources including NASA, the former Royal Aircraft Establishment Satellite Listings, TRW Space Log and Spaceflight magazine. The database is claimed to have an accuracy exceeding 99.9% and, for an additional fee, quarterly updates can be obtained to ensure the accuracy is maintained. There is also the facility for the user to add comments on any object.

Space 2000 is fairly easy to use and searches were very fast on the review computer (a 486 DX type running at 33 MHz under MSDOS 5.1). The user interface is not always consistent and a little idiosyncratic; for example, short quotations and messages written in the first person would appear on screen during searches, sometimes for such a brief time that they were almost subliminal. However, all the search options worked and, generally, Space 2000 appears to be resilient to user input errors. Given its scope and price, Space 2000 is clearly aimed at the serious space researcher rather than casual users. However, the user interface is sufficiently easy to navigate that more casual use could be contemplated, perhaps in educational establishments and libraries.

Quick Search is a smaller version of Space 2000. It is sold as shareware which means that the software may be freely distributed (subject to restrictions given in the files) and, if found to be useful, a registration fee becomes payable to the publisher. Quick Search covers all the launches that Space 2000 holds but, with fewer details on each one, supports fewer search options (there is no facility to create complex queries for example) and there is no on-line help.

Quick Search "feels" very similar to Space 2000 although the lack of on-line help implies it would be more suitable for users possessing some prior knowledge of the subject. The strength of Quick Search is its coverage of launches and ability to provide outline results using simple search criteria. Given this strength and the inexpensive pricing, Quick Search should interest all space enthusiasts.

These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.
Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

'Ulysses Spacecraft' Competition

A five-year journey is taking the Ulysses spacecraft through the uncharted third dimension of the Solar System and over the poles of the Sun. A close encounter with Jupiter in 1992 was used to turn it out of the plane of the orbits of the Earth and other planets. Since then it has journeyed inwards to the Sun reaching the Sun's south polar regions in late June of this year. Now under the control of the Sun's gravity, it is orbiting round the Sun from its southern to its northern hemisphere and will pass over the Sun's north polar regions later in 1995.

This month's competition is an opportunity for readers to consider the component parts of this interesting spacecraft and perhaps win a prize.

Prizes: The first four correct entries to be opened after the closing date of 6 October 1994 will receive a copy of the book:

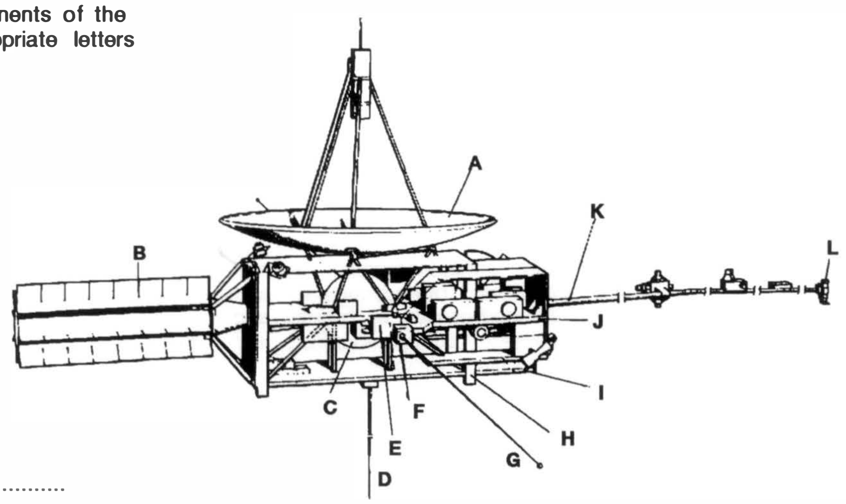
Moon Shoot

by Alan Shepard and Deke Slayton

Details of this book and its publication appear in Book Notices on p.323.

To Enter: Identify the following 12 components of the Ulysses spacecraft by entering the appropriate letters in the spaces provided:

1. Longeron ....
2. Wire boom ....
3. Axial boom ....
4. Radial boom ....
5. Magnetometer ....
6. Wire boom drive ....
7. Thruster cluster ....
8. High-gain antenna ....
9. Equipment platform ....
10. Spacecraft radiator ....
11. Reaction control equipment tank ....
12. Radio-isotope thermoelectric generator ......



Title/Name ....

Address ....

....

....

Post to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England
To arrive by first delivery on 6 October 1994.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

'Apollo Missions' Competition Winners

Winners to whom book prizes will shortly be dispatched are:

First prize: R. Ward UK

Consolation prizes:

M. Rayman	USA
A.A. Evans	UK
H. Gust	Germany
L. Morris	UK

The correct answers are: 1. Spider; 2. Eagle; 3. Young; 4. Shorty.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated. ***Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.*** It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight/JBIS*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

7 September 1994 7 - 8.30 pm

What Must We Change For Low Cost Space: Management, Politics or Technology

C.J. Elliott

Early space programmes were cheap and effective, whereas a mission like Envisat takes 15 years and costs 1500MAU. This lecture examines the drivers that force up the costs of space missions and seeks ways that might lead to falling costs and shorter development times.

13 September 1994 7 - 8.30 pm

BIOS 3 and Biospherics

Nicolai Pechurkin and Lydia Somova

The lecture will be presented by Professor Nicholai Pechurkin of the Institute of Biophysics, Krasnoyarsk, Eastern Siberia. This is the home of the BIOS-series of experiments that first demonstrated the ability of men to co-exist with plants and biological species in a closed habitat.

The subject of life support at a planetary level and the role of BIOS-3 and Biosphere 2 as experimental simulators will be reviewed. These have been used to study food webs, biotic cycles and interactions with energy flows into and within the system. It is clear much has still to be learnt about the laws of biotic cycling and man's role in this activity. His ability to travel and live in space for long periods of time will depend on this knowledge.

15 September 1994 5.30 pm for 6.00

Advanced Launchers

to be held in The Royal Aeronautical Society Lecture Room 4 Hamilton Place, London W1V 0BQ

R.C. Parkinson

Studies in progress in Europe for selecting a future launch system are summarised and criteria for making an eventual choice are suggested.

R. Varvill

The economic objectives and design of the Skylon spaceplane and the Sabre engines which propel it are described.

No tickets required and visitors welcome. Refreshments will be availabe from 5.30pm. This lecture has the cosponsorship of the Society.

Symposium

Space Transportation and Infrastructure

to be held on Thursday, 15th September 1994, 10 am - 4.30 pm at

The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ

ESA's technology programme in Europe and the testing of the McDonnell Douglas DC-X have moved consideration of advanced reusable launchers into a new phase. To report the latest UK work the BIS is holding another in its successful series of Space Transportation Symposia. It was these symposia in the early eighties that started both HOTOL and the Polar Platform.

R. Varvill, Reaction Engines Ltd., Oxon, UK
The Skylon Spaceplane

A. Bond, Reaction Engines Ltd., Oxon, UK
The Architecture of the Space Infrastructure with Advanced Spaceplanes

R.J. Hannigan, ESYS Ltd., Guildford, UK
Role of Demonstrators in the Development of Reusable Space Transportation Systems

D. Ashford, Bristol Spaceplanes Ltd., Bristol, UK
The Spacecab Low Cost Spaceplane - An Update

C.M. Hempsell, University of Bristol
A Comparison of Manned and Unmanned Infrastructures

Dr R.C. Parkinson, British Aerospace (Space Systems) Ltd
Strategy for a Future Launch System

Advanced Registration is necessary. Limited undergraduate student concessions available on request.

***Registration*: Forms available from the Executive Secretary. Please enclose a sae.**

24 September 1994 4 pm

Claude Nicollier Lecture

to be held at the Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1.

Further details appear on p.307.

6 October 1994 7 - 8.30 pm

The First Manned Lunar Landing Spacecraft: Its Design, Manufacture, Ground Test and Mission

R. Fleisig

The Apollo 11 space vehicle is described with emphasis on Lunar Module 5 (LM-5). Finally the mission itself with LM trajectories is reviewed.

2 November 1994 7 - 8.30 pm

Chinese Space Programme

P. Clark

A review of the programme's history, a look at its current status and an attempt to predict in which directions we can reasonably expect the programme to continue.

7 December 1994 7 - 8.30 pm

Collision of Comet Shoemaker-Levy 9 with Jupiter

I.P. Williams

The impact of Comet Shoemaker-Levy 9 with Jupiter provided the world with a spectacular event, images of which were reproduced widely on Television and the Press. However the event was more than a spectacle. New information was obtained on the dynamics of orbits, the structure of SL9, the composition of SL9, the atmosphere of Jupiter and the structure of the planet. The talk will show many of the images and give an overview of the new results.

SYMPOSIUM & CONFERENCES

29 August - 1 September 1994

Practical Robotic Interstellar Flight: Are We Ready?

New York University
(9am - 5pm on four days)
The UN (evening 30 August)

Technical Sessions: Interstellar Flight Concepts; Spacecraft Engineering Considerations; Extrasolar Planetary Systems; Intermediate Prestellar Destinations.

Cosponsored by the Society in conjunction with 11 other organisations.

15 September 1994 10-4.30 pm

Space Transportation and Infrastructure

For details see above.

9-14 October 1994

45th IAF Congress "Space and Cooperation for Tomorrow's World"

The 45th Congress of the International Astronautical Federation will be held in Jerusalem, Israel, October 9-14, 1994. There are 98 technical sessions planned.
A large exhibition on space technology will be held with exhibitors for Israel and other countries.
Details of the programme are available from the Society. Please enclose a 19p stamp.

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Spaceflight

The International Magazine of Space and Astronautics

Apollo Look-Back

Kennedy: A Reassessment
Apollo's Enduring Legacies
Astronauts' Anniversary Meet

Orbiter Endeavour on the Move

- Russia's Commercial Potential
- Shuttle Mission Reports
- Soviet Military Space Station
- Space Launches and News
- Vandenberg Shuttle Facilities

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Spaceflight

The International Magazine of Space and Astronautics

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Vol. 36 No. 10 October 1994

Russia's Commercial Potential

Apollo Look-Back

Features

News & Events

Space Miscellany

Front Cover: **The orbiter Endeavour being rolled over from the Orbiter Processing Facility to the Vehicle Assembly Building to be mated with its external tank and twin solid rocket boosters in preparation for launch on 18 August. For what happened at T minus 0, see p.333.** NASA

State-of-the-Art Launch Facilities

Zenit at Baikonur

Unique Automated Launch System

The aerospace industry is discovering that, as the former Soviet Union emerges into the world of capitalism, they have launch facilities and booster systems that western commercial space operators would like to access; specifically, the Zenit launch and the ground support facilities located at the Baikonur Cosmodrome. This centre utilises a high degree of automation for unattended operations and rapid launch deployment. The Zenit booster is a highly reliable and relatively inexpensive rocket particularly suited to commercial operations. Additionally, the Zenit is scheduled for conversion to man-rated flight status and will replace the older Soyuz rocket.

Because of recent cooperative agreements with western industrial giants like Lockheed, many of the unique aspects of the entire Zenit system will become well known. Here is a brief highlight of some of the advanced technical features used in that system.

BY JOHN ROSSIE
and
JEFF FORREST
Terra Firma Technologies, Colorado, USA

One of the most sophisticated launch facilities in the world is the Baikonur Cosmodrome. Baikonur has an international reputation as a leader in effective, efficient rocket deployment and in rapid launch turnaround time. The success of the Baikonur facility is attributed to fully automated launch complexes and unique integrated systems.

Baikonur, home of the Zenit, is located in Kazakhstan, 150 miles northeast of the Aral Sea in what is now the Commonwealth of Independent States of the former Soviet Union. Baikonur is the largest rocket preparation and launch complex in the world in both geographic area and structural facilities. The Cosmodrome has operated at this location since 1948. Scattered across the site are more than 100 structures that have been designed to assemble, test and launch space carrier rockets. Over one thousand successful launches have been conducted from Baikonur.

The Zenit complex at Baikonur was completed in 1985. Its facilities range from supply and service sheds to multi-storey buildings capable of horizontally processing several Zenit rockets simultaneously. Entrances to large sub-surface areas can be spotted at various locations across the complex. A network of service roads, railroads and underground transportation routes connect and transport personnel and supplies to each key location. Dome-like structures, resembling bunkers, are situated within each Zenit launch site. An extensive array of power cables and piping extend from each dome, giving a "hub and spoke" appearance to each site. Lighting towers for night operations that stand approximately twice the height of the Zenit booster surround each launch pad.

The Zenit booster rocket has recently been approved for commercial operations. It is capable of launching up to 1.7 metric tons of payload into high Earth orbits and planetary trajectories from Baikonur, and 2.6 tons if launched from the equator.

Observing a Zenit preparation and lift-off provides insight into the state of the art in launch methodology. The Zenit is constructed and handled as a single block unit. Testing and integration of each Zenit is conducted in structures approximately six stories high and long enough to contain the horizontally positioned rocket and payload. An extensive system of ceiling mounted cranes is used to position the Zenit rocket and its payloads. The cranes are also capable of lifting an entire booster with payload for placement on a rail car known as the Transport and Mounting Unit (TMU). Technicians are stationed at critical points within the building to monitor the automated configuration process and crane operations.

The TMU can transfer a horizontally loaded Zenit booster and payload to any launch pad within minutes of leaving the integration facility. To accomplish this requires massive ring clamps and hydraulic lifters mounted on customised flat bed rail cars.

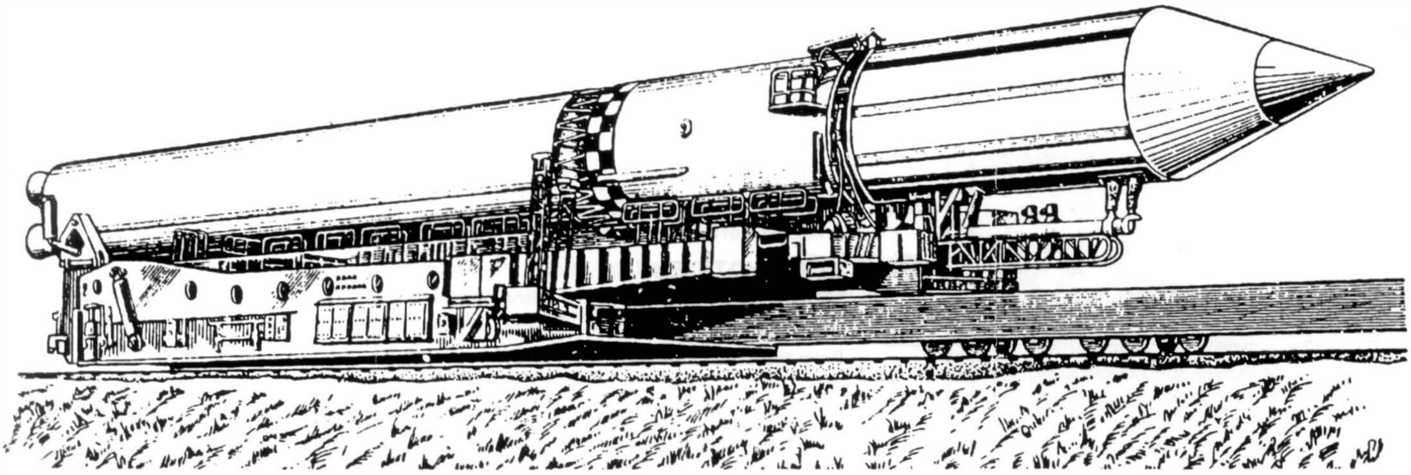
The fully loaded TMU follows an extensive rail track system from the Zenit integration facility directly to a launching pad. Shortly after the TMU

About the Authors

John Rossie and Jeff Forrest spent the last year interfacing with Russian and Ukrainian aerospace manufacturers reviewing existing promotional materials to prepare them for Western dissemination. Their review of relatively unknown elements regarding the automation of Zenit facilities at Baikonur, including meetings with Vjacheslav Filin of NPO Energiya and Yuri Smetanin of NPO Yuzhnoye, inspired them to prepare this brief overview of the Zenit capabilities.

John Rossie, FBIS, has 16 years experience in aerospace activities and holds Masters Degrees in Philosophy, Telecommunications and Information Systems. Jeff Forrest has 5 years experience in aerospace activities and holds a Masters Degree in Space Systems Management.

The Zenit launch vehicle is horizontally integrated and transported to the launch pad at Baikonur.



begins its journey, the launch pad "springs to life" with activity conducted strictly by robotics and remotely controlled equipment. A robotics mating unit and an umbilical tower are used to integrate the Zenit carrier rocket and payload with all required ground preparation and support equipment. A large pole, or guide rail swings into position to receive the Zenit and the mounting unit from the TMU. Doors, flaps and covers automatically retract to expose electrical, pneumatic and fuel lines which connect to the rocket without human intervention. In approximately 2.5 minutes, the computer-aided remote control system connects 3,500 electrical circuits and 25 gas and fuel lines.

Highly polished steel connectors automatically extend and securely seal themselves to the Zenit as it approaches the launch pad. The Zenit mounting unit is then hydraulically lifted into vertical position similar to raising a drawbridge. The rocket is then "clamped" onto the pad with hydraulic and mechanical mechanisms resembling large vice grips. These clamps are so strong that the Zenit can be "throttled up" to full power and kept stationary. This system ensures the stability of the rocket both in cases of scheduled launches and in case of unanticipated engine shutdown. An automatic laser positioning sensor targets the rocket and verifies stability throughout launch operations.

Once secured to the pad, the rocket is fuelled within minutes by subsurface pumps. A fuel manufacturing plant is located underground next to each launch site. Fuel and coolant are stored in large spherical tanks above ground. This insures the Zenit rocket system an immediate and continuous supply of fuel and compressed gases (LOX, high grade RP-1, nitrogen and helium) upon demand. A network of drains and underground piping collects accidental fuel spills. All such contaminants drain into steel containers and are immediately neutralised.

During deployment and initialisation, the Zenit is environmentally controlled by remote computer operation. A unique temperature control system, based on gas expansion and fluid dynamics, was designed to maintain a specific temperature between 5C and 35 C with an accuracy of plus-or-minus 1C.

A computer-aided remote control system also manages the entire launch sequence, allowing operators and mission specialist to supervise the launch progress from remote locations.

A system of built-in sprinkler devices provides the distribution of several fire retardants including Chladon, water and nitrogen. During launch initialisation, large fire extinguishers mounted on turrets are raised and pointed at strategic locations around the launch complex in case of an emergency.

Twelve minutes before launch, support connections such as hoses and fuel lines are automatically disengaged and return to their initial storage compartments where they remain ready for the next launch. Four minutes prior to launch, the TMU rail car retraces its path to the integration station for immediate reloading of another Zenit booster. Many other structures are automatically removed from the launch site or are enclosed in protective cover.

At fifteen seconds before launch, the cooling system is activated. Four cubic metres of water per second are fed into the blast pit directly beneath the rocket engines. The water keeps the temperature of the gas deflector surface below 900C and helps control acoustic vibration.

Within five hours after each launch, the pad is automatically re-configured for the next Zenit launch. The ground support complex, designed to assemble, test and launch the Zenit rocket, is an unparalleled tribute to the Russian mastery of mechanical and aerospace sciences. The Zenit complex operates with the utmost in economy, efficiency and precision. There has never been an accident due to the failure of the Zenit ground support system since its inauguration in 1985. The Baikonur-Zenit automated launch system offers the aerospace industry many benefits for commercial launch applications. ■

Cosmodrome Visit

On 20 March 1994 US Secretary of Defense Dr William J. Perry visited the Baikonur cosmodrome. In so doing he became the first US Government Official of cabinet level to tour this once secret but now relatively open 600 square mile facility.

Defense Secretary Perry said, "No place could more appropriately symbolise the change (in US-Russian relations) than Baikonur".

The Secretary was accompanied by Kazakh, CIS and Russian space and defence officials as well as a considerable group of US officials.

The visit reciprocated several US visits by CIS officials especially Col. Gen. Vladimir L. Ivanov, Chief of the directorate of Space Systems Units of the Strategic Deterrence Units responsible for all Russian space launches.

Col. Gen. Ivanov visited several space facilities in the US including the Kennedy Space Center/Cape Canaveral, the US equivalent of the Kazakh/Russian Baikonur cosmodrome.

Secretary Perry along with Col. Gen. V.L. Ivanov in the Energiya/N1-L3 assembly building viewing Energiya.
US DEPARTMENT OF DEFENSE

A reception with Secretary of Defense Perry talking with Kazakh Space Agency Chief Lt. Gen. Aubakirov Zokhtar, a pilot cosmonaut in his own right.
US DEPARTMENT OF DEFENSE

The tour was not heavily publicised. The exchange of these all too brief tours is intended to show that the "Cold War" rivalry is over and that further cooperation is to follow.

There was only time for the Secretary to visit a few facilities. He and his group visited the Sputnik/Soyuz/Progress launch pad while the Progress-M22 booster was being prepared for launch to Mir on 22 March 1994. They also visited the Energiya N1-L3 horizontal assembly building.

Bob Clark - a NASA official accompanying the US group noted that, "Ground crews for Soyuz manned flights can prepare the pad for a new launch only six hours after one capsule takes off". "Cape Canaveral's turnaround time is one month", (minimal). "Their performance is world class".

Vice US Joint Chief of Staff, Admiral Owens, noted the amazing quality workmanship of the welds on the Soyuz booster. He characterised them as "superb". "They can't be equalled".

CHARLES P. VICK

Thirty Spacecraft Launches Achieved by Russia in 1994 by Late August

Cosmos 2290, a military reconnaissance satellite, was launched on 26 August by a Zenit-2 rocket from Baikonur. The Military Space Forces announced that this successful launch was the 30th one in 1994. This means that Russia is still achieving spacecraft launches at a rate of one per week.

THEO PIRARD

Commercial Space Policy

Aerospace Privatisation in Russia

Combined with other recently announced government measures, the proposed privatisation of NPO Energiya will further strengthen Russia's space industries at a time when they are playing an increasingly important commercial role internationally.

BY MARKO MILIVOJEVIC
University of Bradford

NPO Energiya

The proposed privatisation of NPO Energiya, which is the dominant enterprise in Russia's space industry (RSI), has recently been authorised by presidential decree and began this year with the offer of 49% of its equity to its management and employees, other Russian citizens, and institutional investors, including foreign interests.

As with the proposed privatisation of other key enterprises in RSI, private ownership of NPO Energiya will be phased in gradually, with the government retaining a 51% controlling interest in the enterprise for the next three years. Although initially capitalised at only 1 billion roubles (US$650,000), the Moscow-based NPO Energiya, which has 30,000 employees nationwide, is worth far more on the open market. One of the major reasons for this is the recent success of NPO Energiya's General-Director, Yuri Semenov, in attracting substantial foreign capital into the company. In this context, NASA has recently agreed to provide up to US$400 million over the next four years to RSI, most of which will go to NPO Energiya for the supply of various major systems for the International Space Station.

Commercial Launch Growth

In addition to this NASA finance, NPO Energiya and other key enterprises in RSI presently envisage increasing foreign exchange (forex) earnings from the launch of foreign satellites and the use of Mir for long-term manned commercial tasks in space. A major deal was signed in December 1993, when a consortium consisting of NPO Energiya, the Krunichev Enterprise (a former subsidiary of NPO Energiya that manufactures Proton) and Lockheed (as external marketer of Proton launch services to foreign satellite operations) teamed up with the Palo-Alto-based US Space Systems (USSS, a part of the Loral Company) to launch up to five telecommunications relay satellites for around US$250 million.

In 1993, the two major enterprises of RSI earned a record US$150 million from the local launch of foreign satellites. This is in comparison with 1992 when the Russian Space Agency (RSA), which exercises overall control of RSI and the RSP, entered into its first foreign commercial satellite launch contract with Inmarsat and the annual total was just US$75 million. Following the recent deal with USSS, forex revenues from such launches and other services in 1994 could be double or even treble the 1993 total.

Price Competition and Protectionism

As with the Inmarsat launch contract in 1992, lower launch fees are the basis of Russia's international commercial success. The Krunichev Enterprise charged US$46 million in 1993 to carry an average satellite payload into space on its Proton rocket, which has had a 96% success rate since its first version was introduced in 1967. By way of contrast, Arianespace charged US$62 million per launch on the Ariane rocket. Similar exorbitant quasi-monopolistic satellite launch charges are also the norm in the US.

Among other things, this large price disparity has resulted in intensive lobbying by alarmed US and European aerospace interests. In the US it paid off in December 1993, when Washington unilaterally limited the number of US satellite launches on Russian rockets to eight until 2000, while insisting that Russian satellite launch prices be similar to those of western firms. (Presently, therefore, any Russian bid more than 7.5% cheaper than the lowest US or European offer results in automatic inter-governmental consultations between the governments involved). Although clearly protectionist and possibly in breach of US and European Union (EU) anti-trust laws, this informal "quota" would be very difficult to enforce in practice, with the recent USSS deal alone accounting for over 50% of the proposed limitation for the next six years.

Although RSA chief Yuri Koptiev intimated in February 1993 that Russia was prepared to accept an annual quota of 3-4 commercial satellite launches per year, or 25% of the world market in 1993, such unilaterally imposed restrictions by western governments could well result in a more aggressive Russian stance. We have already seen the RSA deny western government charges that it is deliberately price-cutting on the satellite launch front in order to boost forex earnings and increase market share still further. Among western satellite operators, few believe that the present western quotas can be enforced. The consensus of opinion among such operators, most of whom are US-based, is that the Krunichev Enterprise will come out top of this conflict.

Some top US aerospace manufacturers are totally opposed to anti-Russian protectionism, arguing instead that abolishing quotas on Russian launches of foreign satellites could stimulate growth by lowering prices throughout the global commercial space sector. Lockheed's partnership with NPO Energiya and the Krunichev Enterprise is a case in point. Lockheed has also pointed out that the whole purpose of NASA's recent deal with RSI was to take advantage of its lower prices, without which the agency's proposed International Space Station would never have got as far as the US Congress. Forcing RSI to raise prices externally is thus economically and politically harmful to key US aerospace interests. For Lockheed, and therefore NASA, RSI are vital allies, which no doubt explains why NASA allowed a Russian astronaut on to its space shuttle for the first time in February 1994.

Price Rises Foreseen

Longer-term, however, Russian satellite launch prices and fees for other services in space will almost certainly have to be sharply increased, with domestic cost-plus inflation the basic cause of this. The 1993 satellite launch prices charged by Krunichev Enterprises were substantially up on those of 1992 (US$46 million as opposed to US$36 million for the first Inmarsat launches). Price rises are inevitable in 1994, the recent USSS deal having been provisionally priced at US$50 million per satellite launch.

Another factor affecting prices is the conflict over the Baikonur cosmodrome in Kazakhstan, whose government plans to assert control over it, beginning with substantially increased launch, site leasehold and other fees in 1994 (payable in forex). At worst, Kazakhstan could ask the RSA to vacate the facility, which is the only one in the CIS that can handle Proton launches. Building a new and fully secure Proton launch facility in Russia would be very expensive.

New Investment Needs

The Rus rocket which is the proposed replacement for the aging Proton series, has reportedly experienced large cost overruns with Krunichev Enterprises now unlikely to deploy it within its agreed budget by a 1996 target date.

Politically, the Rus project has also been bedevilled by factional in-fighting between the RSA, Krunichev Enterprises and the Defence Ministry's Strategic Space Forces. A lower than

expected Rus production is also expected, which will threaten the RSA's ambitious plan to radically increase the number of annual satellite launches - domestic and foreign - during the 1990s.

Technically, and most importantly of all, Rus will almost certainly require western capital and technological inputs, but it is not at all clear whether the US, the world leader in booster technology, is prepared to provide them, mainly because Washington is concerned by related military aspects.

Similar cost, technical, political and production problems have seriously affected NPO Energiya's series of new satellite systems, including Express and Gal, which will respectively replace the ageing Gorizont-type (communications) and Ekran-type (direct broadcasting) satellites in the 1990s. Combined with the new Marathon system, these new proposed satellite systems will, inter alia, create an additional 70,000 telephone traffic channels by year 2000, and as such are to be the bedrock of future inter-regional telecommunications in the Far North, Siberia and the Far East.

As regards global communications, NPO Energiya's Sovcanstar system which has set up a production joint venture with Spar Aerospace of Canada, is another top priority, although the funding for it has been drastically curtailed by government since 1991. Such joint ventures have been relatively rare to date because Russia is a powerful competitor in the world space industry and western governments, led by the US, are still unwilling to provide state-of-the art satellite technologies that are security-related.

In this context, it is beyond dispute that the powerful Defence Ministry is seeking to upgrade its top secret spy satellites, which are still used against western countries (who are also spying on Russia). A particular area of interest is the development of radio-transmitted and encoded image data systems, which are standard in the west, but relatively new in Russia, where old-fashioned descent modules are still used to recover data recorded by some of the older Russian satellites.

In the commercial sector, the development of radio transmission systems for use on the main international frequencies is an absolute must. The RSA's three main ground-based control-data-processing facilities at Novosibirsk and Khabarovsk (tracking stations) and Priroda (the data-processing and control nerve centre of the entire RSP near Moscow) need to be technically upgraded. Like everything else in the RSP, it is presently unclear how such major projects will be financed. Earlier, during the Soviet period, the RSP was relatively well-financed, but since 1991 it has experienced acute under-funding.

Investment Prospects for RSA

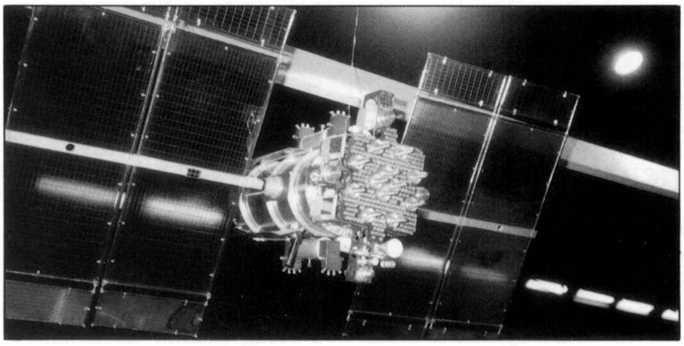
It is the shortage of new investment that is ultimately behind the government's proposed privatisation of RSI and its present international commercial orientation. On the domestic front, and in addition to the present privatisation programme, the government has already recently announced a number of other measures to help RSI.

In November 1993, it was announced that public spending on the RSA would be increased for the first time in real terms since 1991. In this contest, a consolidated space budget of 320 billion roubles was set for 1994, subject to final confirmation by the new Duma. In addition, in an unusual move, 40% of the year's budgetary allocation would be disbursed to the RSA during the first quarter of 1994, which has reportedly been done.

The actual Russian space budget is thought to be even larger with many expenditures hidden in the defence budget. Politically, this reflects the strengthened position of the Russian armed forces following President Yeltsin's forcible dissolution of the old parliament in September 1993. Among other things, this new emphasis on military space programmes will

Russia's Ten-Year Programme

The Russian Space Agency has made public its programme for the next ten years which gives priority, for the first time, to the development of satellite communications, which are much needed to cover its immense territory economically.



Navigation satellite of the Glonass system. Th. P. / SIC

On 19 August at the International Space Congress in Moscow, the Russian Space Agency announced the following main features of its future space programme.

With the help of such satellite systems as Gals, Express and Marathon, the development of which is being funded mainly on a commercial basis, the number of television channels in the Russian Federation is expected to increase from 2-3 to 7-8.

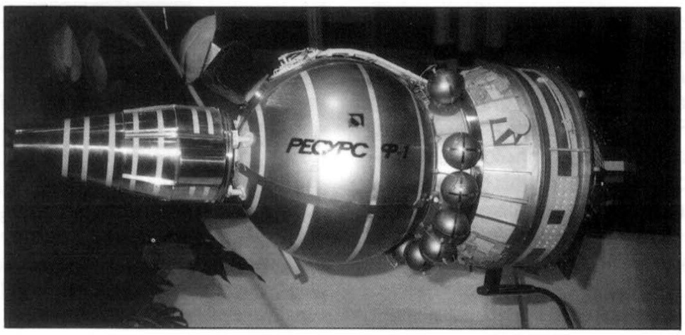
The Glonass and Nadezhda (Hope) systems will help increase the accuracy of navigation, effectiveness of transport management and support search and rescue operations.

Space environmental monitoring, weather forecasting, geological prospecting and harvest assessing will be facilitated by satellites in the Resurs (Resource), Almaz and Meteor series. Picture-definition and areas "captured" in such pictures are expected to double and weather forecasts will cover up to seven to ten days instead of two to three days as at present.

The Russian Space Agency is planning to remain in the lead in the field of manned flights with more experiments aboard the Russian space station Mir and work aboard the future International Space Station. All space missions planned for the near future will be carried out on a commercial basis with the participation of representatives of foreign countries. Apart from economic gains, such missions will help accumulate experience for joint work aboard the International Space Station.

The Russian Space Agency sees future exploration of the Moon and Mars as possible only in cooperation with other countries.

Resurs F satellite for remote sensing. Th. P. / SIC



result in an extra 10,000 personnel for RSI, which had earlier suffered an exodus of 40,000 staff due to low pay and poor working conditions In the post-1991 period. In addition, this extra government funding may have the effect of slowing the conversion of some RSI enterprises which, earlier had been opposed by powerful figures in the Defence Ministry and the Duma's *Commission for Transportation, Communications, Computers and Space* (CTCCS), which oversees the work of the RSA and provides strategic guidance for the RSP as a whole.

Politically, the CTCCS now has to begin work on the creation of a new legal-regulatory regime for the RSP, beginning with the drafting of two new proposed laws to define the role of state agencies and the private-sector in the field of space applications. Although this work was started by the RSA in conjunction with the CTCCS of the old parliament, it was suspended by the events of September 1993 and the later parliamentary elections in Russia. As in 1993, the new legal-regulatory regime is expected to formally authorise a greater role for the private sector in RSI, although the state will retain its hitherto dominant position for at least the next three years. In practice, its strategic dominance will last even longer, given the close involvement of the Defence Ministry in all aspects of RSI and the RSP as a whole.

As regards possible increased direct foreign investment in RSI, which could begin to take place through the later stages of the present privatisation programme, the prospects are relatively favourable in spite of a strong current of opinion in both the Defence Ministry and the CTCCS that foreign equity purchases in RSI should be avoided on security and political grounds. For such nationalist forces, foreign capital and technological infusions without a dilution of direct control are far more politically palatable, the recent deal with NASA being the ideal arrangement from their point of view.

NPO Energiya and other enterprises in RSI are now determined to use their proposed privatisation to increase their ability to act as normal businesses, particularly overseas. This could conceivably create tensions with a number of powerful authorities in Moscow, which will be reluctant to cede any effective control of so valuable and strategic a sector as RSI and the RSP as a whole.

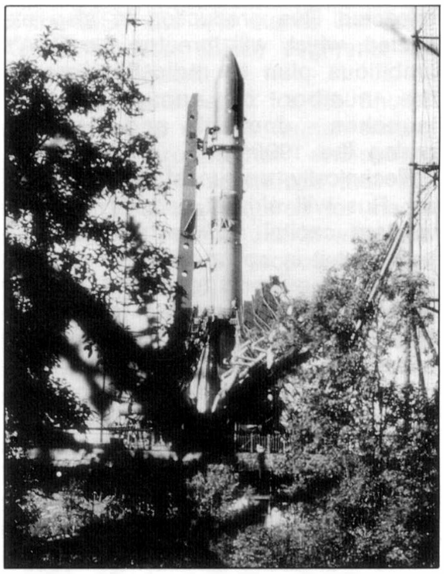
In conclusion it can be said that, although still afflicted by a number of major problems, RSI has relatively good future prospects due to recent government measures and a real comparative advantage internationally that is likely to further strengthen its position in 1994 and thereafter. ■

Microgravity Joint Project

On 14 June, a Russian spacecraft with a recoverable capsule of 3 tons, under the name of Foton 9, was launched by a Soyuz rocket from the Northern cosmodrome of Plesetsk. (Its designation in correct sequential order would be Foton 6 (not 9) - see Satellite Digest-268, September 1994). The mission had a duration of 15 days and the capsule was successfully recovered in Kazakhstan on 2 July.

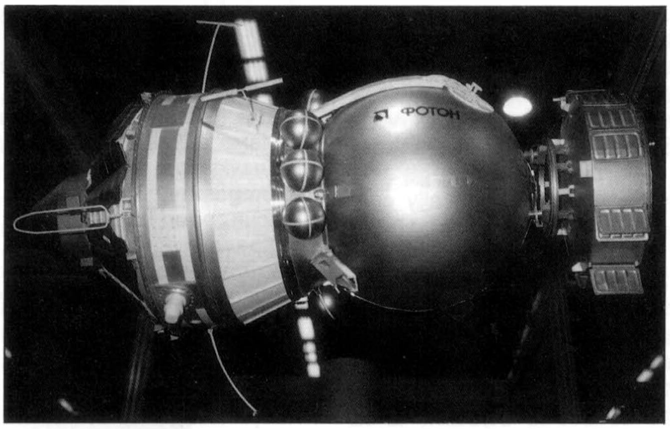
The spacecraft carried an international microgravity payload, consisting of:

- The French experiment Gezon to study the melting of materials in space environment, with the use of the Russian Zona-4M oven developed by the Splav centre of Moscow.
- The European Biopan facility to study how several biological samples (amino acids and peptides, responsible for life on Earth) can survive a trip through space. Biopan was developed by the German firm Kayser-Threde for ESA.



Soyuz launch vehicle in preparation at Plesetsk. Coll. SIC

The Foton spacecraft for microgravity research. Th.P./SIC



McDonnell Douglas in Russian Tie-Up

McDonnell Douglas has signed two agreements with Russian aerospace organizations to advance the development of future US and Russian space programmes.

A memorandum of agreement signed with the Central Specialized Design Bureau and PROGRESS factory of Samara, Russia covers several possible areas of cooperation in launch vehicle activities, including launch vehicle stages, ground support systems and system components.

A similar memorandum with the Central Research Institute for Special Machine Building of Khotkovo, Moscow region, Russia involves unpressurized composite structures and various composite fabrication techniques and materials.

"Our objective is to develop qualified Russian suppliers for our launch vehicle products," said Dave Wensley, vice president and general manager, strategic business development. "These particular agreements may lead to the procurement of materials and components for McDonnell Douglas products."

Russian-Japanese Cooperation Picks Up

Japan is expected to participate in the construction of the International Space Station. Since 1986, Japan has been developing a shuttle spacecraft "Hope" which is planned for use in the future construction of a module in which superpure substances are to be produced. The Japanese spacecraft will be tested at the Russian technical base of the Zhukovsky Aerohydrodynamic Institute and the Japanese Space Agency has expressed interest in data from the experimental unmanned mission carried out by the Russian reusable spacecraft "Buran".

Because of political issues a Russia-Japan agreement on cooperation in space exploration has previously born little fruit except in 1990, when Japan paid $25 million for its astronaut to participate in a joint mission and it provided the space centre in Baikonur with some equipment. Now the two countries are negotiating over Japanese participation in Russian "Mir" missions. Japanese microelectronics is of particular interest to Russia, Yuri Koptev Director-General of the Russian Space Agency said.

Space Flight Simulation

Three Russian research volunteers will spend 135 days in full isolation from the outside world aboard a full-size model of the orbiting station Mir in an experiment at the Institute for Biomedical Problems between 1 September 1994 and 14 January 1995.

The experiment is part of the preparations for EUROMIR 95 - a 135-day flight of a joint Russian-European crew - two Russian cosmonauts and one astronaut of the European Space Agency - scheduled for 1995. European astronauts have never been on such long space flights before and ESA requested the Russian institute to carry out the experiment to simulate the future flight. The experiment will be conducted on a commercial basis.

The aim of the experiment, called HUBES (Human Behaviour in Extended Space flight), is to put to test psychological methods used to choose, train and provide medical support for cosmonauts in space flights. Contacts with ground services will be made in the form of communication sessions, except for medics who will contact the crew at least three times a day.

New Pacific Cosmodrome Plans Delayed

An estimated $900 million is needed to fund international plans to build a commercial cosmodrome on an isolated site in Papua New Guinea (*Spaceflight*, March 1994, p. 75).

Under the project, first discussed last year, Russia would supply technical advice, launchers and booster rockets, and help in building and operating the cosmodrome. Australia's Space Transportation Systems (STS) would raise money for the project, which has been approved by the New Guinea government. The first launches are due in 1998, but work has not yet started.

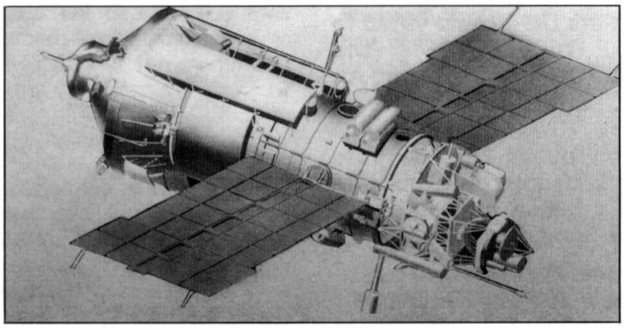
A Proton launch from Baikonur could carry 2.4 tonnes of payload, compared with four tonnes for a launch from the new site. Anatoly Kisilyov, director of the Khrunichev Space Centre, said eight to 10 launches a year would be needed to offset construction costs.

He said he was sure Russian firms could make a profit from space launches from the New Guinea site because the payload of rockets would be bigger than at the Baikonur cosmodrome, where only two or three commercial launches a year can be made because it is also used for military flights and for Russia's space programme.

In the highly competitive world market of space launches, Russia sees space technology and rocket launches as a key area where it can compete with the best in the rest of the world.

The following news reports on this page are provided by:
THEO PIRARD/SPACE INFORMATION CENTER.

Belgian-Russian 'Spectr Module' Experiment



The Spektr module to be launched to Mir. Th. P. / SIC

The Belgian Institute of Space Aeronomy (IASB) is cooperating with the Russian Institute of Cosmic Research (IKI) in the MIRAS experiment to study from low orbit the evolution of atmospheric constituents.

The $20-million MIRAS instrument is being developed in Belgium by the firm Alcatel-ETCA. It will be delivered in two parts to the existing Mir complex aboard the astrophysics Spectr module. This module is planned for launch with the Proton rocket in February 1995 at the earliest and could be delayed until Summer 1995.

The reassembly of the MIRAS experiment and its installation outside the Spectr module will require the EVA of two cosmonauts. Following the initial agreement between the Russian and Belgian Institutes, the MIRAS instrument is to be used with the new core element of Mir-2, now to be part of the International Space Station.

Ukraine Develops Own Programme

The Ukrainian National Space Agency is going ahead with the development of its national space programme with the support of international cooperation.

Ukrainian industry is able to develop and produce rocket engines - it developed the engine of the Soviet Lunar Module - and it manufactures the Cyclone and Zenit launch vehicles, as well as platforms for space science and applications. Its first partner for the use of launch vehicles and launch facilities is the Russian Space Agency.

In late 1995 or early 1996, Ukraine will launch its first satellite, named Citch-1. It is an Okean-type remote sensing satellite using radar systems for Earth observations. Citch-1 will be launched by a Zenit-1 rocket from Plesetsk. For Lieutenant-General Lev Ignatenko, this launch of a "made in Ukraine" spacecraft marks the beginning of a national space programme, independent from the Russian space programme.

The Ukrainian National Space Agency has officially approved cooperation between the Southern Machine-Building Factory (NPO Yuzhnoe) with the French aerospace company Dassault for the development of light satellite launch vehicles.

In the field of space communications, Matra Marconi Space is designing a payload for the geosynchronous satellites of the Lebid system to be used by the Ukraine.

Russia Joins Eutelsat

Russian Federation Communications Ministry, representing Russia, has become the 41st member of the Eutelsat organisation.

Minister Vladimir Bulgak, after having signed the agreement with Eutelsat, pointed out that, from a technical point of view, cooperation between his country and Eutelsat does not present any problems. He stated that Russia would practically double the technical capacity of Eutelsat and could render assistance in putting new generation satellites into orbit.

Russia-Brazil

Russia and Brazil recently discussed the terms of space cooperation between the two countries. Brazil requested technical assistance with critical components for the final development of the all-solid four-stage VLS rocket. First launch of VLS, from the coast of Alcantara, is scheduled to take place late next year.

New East-West Venture

A recent agreement was signed between Khrunichev Enterprises (which produces Proton rockets and ballistic SS-19 missiles) and Deutsche Aerospace concerning the joint production and marketing of launch services with the Rokot launch vehicle.

This launcher will be able to carry up to 1.5 ton to low-orbit and will be particularly suitable to launch Globalstar-type communications satellites.

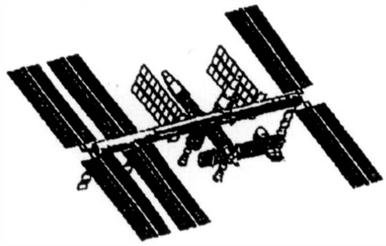
Sea-Based Launcher Development

Recently, Viktor Chernomyrdin, Chairman of the Russian Federation Government, signed a Directive authorising the NPO Energiya corporation to develop, with foreign partners, a sea-based rocket for space launchings.

NPO Energiya would be responsible for coordinating the work in Russia and for cooperation with Ukrainian enterprises.

Senate Funds Space Station

On 3 August, the US Senate voted to retain the funding of the International Space Station. An amendment, offered by Senator Dale Bumpers (D-AR) to terminate funding failed by 64-36. The vote came during a debate on a bill that includes $14.4 billion in funding for NASA for the next financial year.



NASA had said that Russian participation, agreed to last November, would reduce the future US cost of the space station by $2 billion to $17.4 billion by the time it is completed and ready for occupancy in June 2002. However, a General Accounting Office analysis, whose release was timed for the forthcoming vote, said there would be "lower than anticipated contributions of Russian hardware and Russian participation would add a net $400 million in funding requirements".

GAO also said that Russian participation would increase requirements for other NASA programmes that support the space station by at least $1.4 billion.

Under last year's agreement, Russia will supply a space tug for propulsion, guidance, navigation and control, Soyuz capsules to be used as "lifeboats" to go back to Earth in case of emergency and systems for docking the shuttle to the space station.

Near-Earth Objects

On 3 August NASA announced the establishment of an eight-member Near-Earth Object Search Committee to identify and catalogue, to the extent practicable within 10 years, all comets and asteroids which may threaten the Earth.

Dr. Eugene Shoemaker, an astronomer with the Lowell Observatory and professor emeritus with the US Geological Survey, who was co-discoverer of Comet Shoemaker-Levy 9 which collided with Jupiter in July is the Committee's Chairman.

The committee was formed in response to Congressional direction to NASA to develop a plan in coordinationn with the Department of Defense and the space agencies of other countries. The plan's objective is to identify and catalogue, to the extent practicable, the orbital characteristics of all comets and asteroids greater than about 1 km in diameter in orbit around the Sun that cross the orbit of the Earth.

Asia-Pacific Region Strengthens Space

The Preparatory Committee for the Asia-Pacific Space Cooperation Mechanism (Prep-Comm for AP-SCOM) was officially established in Beijing on 11 August with the secretariat set in China.

Representatives from more than 10 countries including Thailand, Pakistan, The Republic of Korea, China, Russia and Indonesia attended the first meeting of the committee whose major task is to raise organizational, management and operational suggestions for the establishment of a regional space cooperation organisation, which will be submitted to the meeting on Asia-Pacific Space Technology and Application planned for 1995 in Pakistan.

Lockheed, Martin Marietta Merge

Lockheed Corporation and Martin Marietta Corporation are to merge through an exchange of common stock valued in excess of $10 billion. The new corporation, Lockheed Martin, will be a highly diversified $23-billion advanced technology company with core business in defence, space, energy, commercial, civil government, and international markets, and will employ approximately 170,000 people.

Skynet 4 Solar Panels

TRW Space & Electronics Group is to fabricate 12 solar panels for two Skynet 4 Stage 2 military communications satellites for the UK. TRW will install more than 12,000 solar cells during construction of these solar panels under a one-year subcontract to Fokker Space & Systems of the Netherlands.

Fokker was recently awarded a contract from British Aerospace to build rigid solar arrays to power the two Skynet 4 Stage 2 satellites. The total panel area of the arrays will measure 338 square feet.

TRW and Fokker Space & Systems have agreed to jointly market the two companies' lines of solar arrays for commercial, military and scientific satellites. Under this agreement, TRW and Fokker will jointly represent their collective interests in the global market. Fokker Space & Systems is the largest company in the Dutch space industry. It is a leader in systems engineering and space technology, including solar arrays and thermal control, simulators and robotics. TRW Space & Electronics Group has built more than 180 communications, scientific and defense spacecraft; developed more than 200 advanced space instruments; and integrated some 550 experiments into spacecraft.

Matra Marconi Space Acquisition

On 9 August, Matra Marconi Space acquired the former Ferranti International Satellite Communications and Microwave Components division based in Poynton, Cheshire, North West England.

The complementary capabilities of the two companies are seen as a welcome addition to the expanding business of Matra Marconi Space in Ground Systems.

The Satellite Communications and Microwave Components (Satcomms) division offers a range of turnkey commercial and military satellite ground systems and sub-systems, as well as a comprehensive range of 'state-of-the-art' microwave components. Satcomms also offers fixed Very Small Aperture Terminals (VSAT's), vehicle mounted mobile and man-portable satellite communications systems for the commercial and military markets.

Matra Marconi Space recently announced its acquisition of BAe Space Systems. It is a joint venture company jointly owned by the Lagardere Group of France and GEC in the UK

Call for Strong Sciences

In the first such national science policy statement since the Carter presidency, the White House has moved away from what had been a major rationale for government support of science for 50 years - winning the Cold War - to announce a pledge to maintain "world leadership in basic science, mathematics and engineering." The new focus is on strengthening science to serve a broad array of "core national interests".

"Technology - the engine of economic growth - creates jobs, builds new industries and improves our standard of living," said Vice President Gore in releasing the document. "Science fuels technology's engine."

The 31-page policy statement, titled "Science in the National Interest," lays out five national goals which will be given high priority in future federal science budgets.

The five are economic prosperity, improved human health, more effective environmental protection, stronger national security and a category called "improved quality of life", which includes discoveries that "ennoble the human spirit" by enriching understanding of the natural world.

In addition to maintaining world leadership in all major areas of science, the new policy proposes four additional goals: to encourage closer ties between fundamental research and the national interest; to stimulate more partnerships among federal and state governments and industry; to strengthen excellence and promote diversity in the education of scientists; and to raise the scientific and technological literacy of the public.

STS-68: Endeavour Launch Abort

A last-second fuel pump problem caused Endeavour's computers to shut down the main engines just 1.9 seconds before liftoff early on 18 August, so aborting a planned 10-day environmental research mission with the second flight of the Space Radar Laboratory payload.

Before the shutdown everything indicated an on-time launch and Endeavour's countdown proceeded smoothly to the T-minus 6.6-second mark when the Shuttle's three main engines began throttling up. "We have a go for main engine start", said NASA commentator Bruce Buckingham from the launch control center. "We have three main engines running . . . three, two, one . . .". Then just 1.9 seconds before Endeavour's twin solid-fuel boosters were to ignite, committing it to flight, it was calmly reported: "We have a cutoff".

The main engines quickly shut down on computer command. Automatic fire extinguishers sprayed water on the rear of the Shuttle and the flames quickly died out. Although NASA's countdown clocks read 00:00:00, the initial shutdown command was issued at T minus 1.9 seconds. It then took each engine several seconds to cut off. The launch abort - the fifth in the history of the Shuttle Program - occurred closer to liftoff than any previous shutdown.

Endeavour's six astronauts climbed out of the shuttle about an hour after the abort. They heard a muffled rumble, felt the engines vibrate, and waited for "that big kick" from the two solid-fuel boosters that ignite at liftoff, "but it never happened".

Preliminary analysis indicates that a sensor monitoring data 50 times a second from main engine No. 3 detected temperatures about 15 degrees higher than predicted in the high-pressure oxidiser turbopump discharge to the main combustion chamber. A second sensor also measured slightly elevated temperatures, although that reading did not violate launch guidelines. Had the Shuttle been in flight, the computers would have permitted the engine to continue operating as long as the second sensor's readings were within limits. Prior to launch, however, NASA's safety rules require that all sensor data are within specified limits.

The next scheduled mission, STS-64 with Discovery, was transported to the adjacent launch pad 39B and ground crews set about preparing it for launch on 9 September as planned.

Endeavour was removed from launch pad 39A and taken to the Vehicle Assembly Building for replacement of its main engines. The second launch attempt has a target launch date of 2 October.

Roelof L. Schuiling provided information for the above report and adds details about the previous four launch aborts:

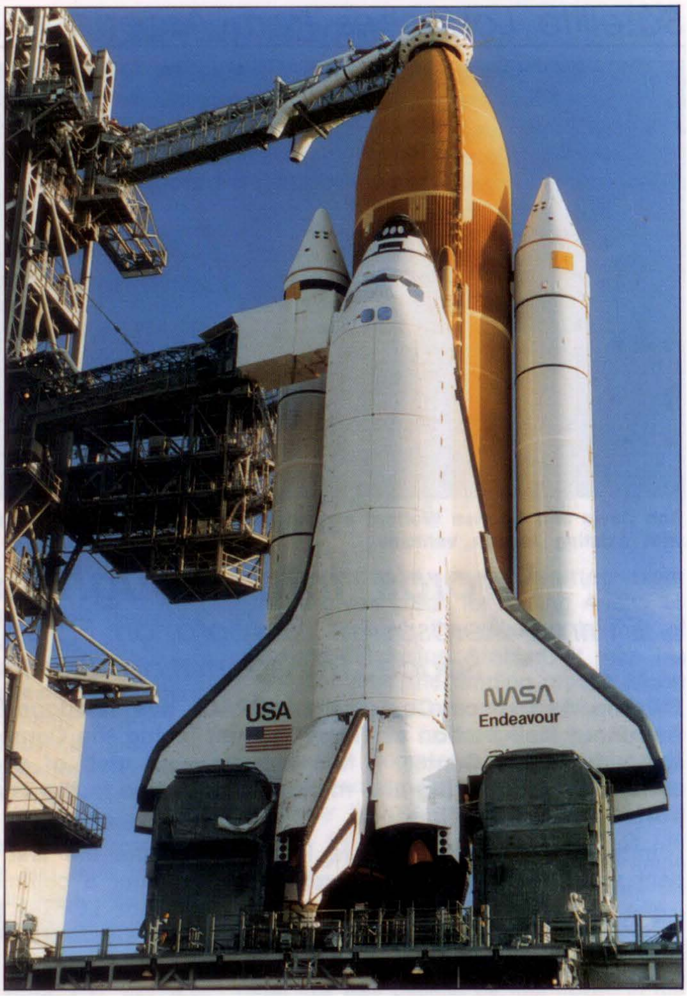
On 26 June 1984 Discovery's STS-41D mission was aborted at T-4 seconds. STS-41D's actual launch date was 30 August 1984.

Challenger experienced an on pad abort on 12 July 1985 when its STS-51F mission aborted at T-3 seconds. STS-51F's launch date was 29 July 1985. STS-51F experienced an engine shutdown in flight and performed an abort-to-orbit.

Columbia experienced another abort on 22 March 1993 when STS-55 was aborted at T-3 seonds. STS-55 was eventually launched on 24 April 1993.

Another 1993 abort occurred when Discovery's STS-51 launch was aborted at T-3 seconds. Discovery's actual STS-51 launch occurred on 12 September 1993.

The launch abort for STS-68 was the first abort for Endeavour and the closest to T-0 in the Shuttle program.



Endeavour sits on launch pad 39A in readiness for lift off on 18 August, but circumstances determined otherwise. NASA

The STS-68 crew pose for a group photograph on 2 August in front of the launch pad with Endeavour in place. The following day, they carried out the Terminal Countdown Demonstration Test, which was a dress rehearsal for the launch. From left are Pilot Terrence W. Wilcutt, Payload Commander Thomas D. Jones, Mission Commander Michael A. Baker and Mission Specialists Steven L. Smith, Peter J.K. "Jeff" Wisoff and Daniel Bursch. NASA

London Lecture

Hubble Repair Mission Astronaut

Claude Nicollier

will talk about his work and the Hubble Repair Mission at The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London at 4 pm on Saturday, 24 September 1994

Members are cordially invited to attend. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets, or telephone 071 735 3160.

Satellite Launches from Ascension Island

BY THEO PIRARD, FBIS
Belgium

Bob Davis and Charles Wofford explain how the Eagle Series rockets are able to compete with existing launch vehicles. Th.P./SIC

Swords into Ploughshares

E'Prime Aerospace Corporation Enters Business of Space Transportation Services

E'Prime Aerospace Corporation (EPAC) has headquarters located at the Astronaut Mall Station at Titusville, just facing the Complex 39 of the NASA Kennedy Space Center. It has a permanent staff of some 12 people concerned by engineering and marketing activities in the sector of space transportation and applications.

In the words of Bob G. Davis, President and Chairman of the Board:

> "EPAC is obtaining clearance from the US START Treaty compliance review group for authority to conduct a launch system verification test or slug test to verify the Eagle Series launch systems integrity, which will be conducted at Vandenberg Air Force Base. We are ready to start the production of the family of Eagle Series launch vehicles with associated contractors, such as Thiokol for the solid boosters, Aerojet for the liquid propulsion systems, Honeywell for the avionics..."

This announcement came after five years of persistent effort by EPAC people to establish a commercial system based on the US Air Force M-X Peacekeeper program. EPAC was established in early 1987 with an initial funding of some $10 million. It claims that on 17 November 1988, it became the first private company to conduct a commercial space launch with the LOFT-1 sounding rocket from Cape Canaveral AFS. Bob Davis summarises:

> "Our purpose is to use existing reliable technology whose deployment for military needs has to be discontinued for political reasons. By employing the mobile ICBM technology, we are developing and marketing efficient launch services for fully private access to space. In this time of budgetary constraints, the only efficient way to go into orbit is the private one. We use quickly available, very reliable and highly performing systems developed in the frame of military programmes. We have come to an agreement with US Air Force to exploit the technology which was successfully tested in 26 M-X Peacekeeper flights until November 1991. The opportunity for EPAC has been conversion of military technology to civilian use. This was possible after August 1992 when the START agreement halted the production of the new ICBM, making it available for space launch operations".

Bob Davis extols the efficiency of the Eagle Series vehicles by comparing them with Delta, Atlas, Ariane, Titan and Long March:

> "The big mistake of these launch vehicles is to use complicated systems with liquid engines, requiring the maintenance of expensive launch facilities and the presence of an important specialised staff for launch operations. After the commercial advent of our space transportation system, Delta, Atlas, Titan and Ariane which employ technologies of the 1950s will be out of the competition."

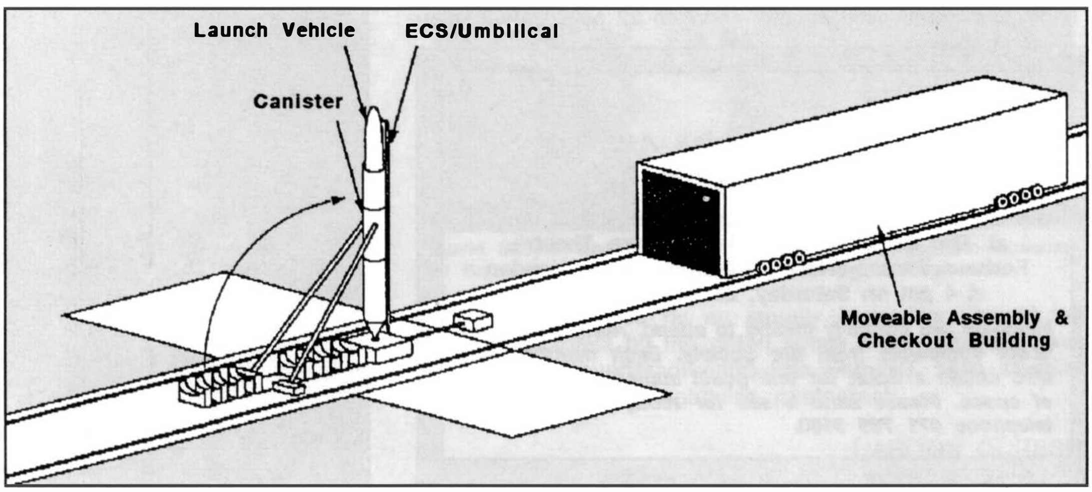
The following Table which is provided by EPAC summarises data for the GEO efficiency ratio (GEO mass:liftoff mass) and for the cost per lb to GEO:

	GEO Efficiency	Cost per lb to GEO
Delta II 7925	0.40%	$40,000
Atlas-Centaur	0.92%	$16,771
Titan IV-IUS	0.31%	$47,758
Ariane IV	0.50%	$30,769
Long March 3	0.32%	NA
Eagle S-III/USTM	1.22%	$9,375*

* Assuming a launch price of around $30 million.

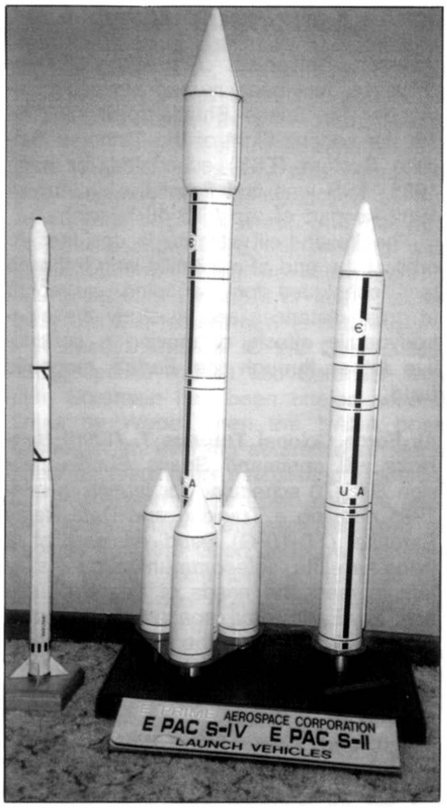
USTM is an unified biliquid perigee/apogee system for GEO missions. Designed by Bob Davis and Charles Wofford, it offers the basic structure of spacecraft for communications and broadcasting satellites and it uses a restartable engine with high specific impulse.

The Eagle Series launch vehicles will be proposed for launches from Ascension Island for geosynchronous satellites and from Vandenberg Air Force Base for polar spacecraft.



Assembly and Launch Facility, Ascension Island. The facility would also include a remote Launch Control Center with a RF/Laser Control/Telemetry Link to the launch pad.

BASED ON INFORMATION SUPPLIED BY EPAC



Two EPAC launch vehicles, based upon the technology of the M-X Peacekeeper ICBM of the US Air Force are compared to the now discontinued Scout launch vehicle (left). Eagle S-II is the current launch vehicle in preparation. Th.P./SIC

EPAC engineer Charles Wofford explained:

"Our services don't require expensive launch facilities. The Eagle vehicle is being prepared in a horizontal position inside a moveable building with a clean room environment. Once fully integrated with the payload, it is moved inside a canister into a vertical position. The originality of the Eagle rocket is that it is to be ejected by 42-gallons of steam water from a canister, named the Launch Eject Gas Generator (LEGG), up to 200 feet altitude; then it is ignited 1 or 2 seconds after lift-off. No flame trench is required. No sound suppression with water, no expensive refurbishment. Quick turnaround is guaranteed. The launch of an Eagle Series will require a team of only 10 people!".

For launch operations, EPAC has to build a low-cost infrastructure (assembly and launch facilities) at Ascension Island on a site called Devils Ashpit, in a former volcanic region. The site is accessible by road from the Wideawake Airfield, which can be used by heavy transport aircraft. EPAC hopes to obtain the cooperation of British Cable & Wireless for the lease of tracking stations on Amirante Island (Seychelles archipelago) and on Diego Garcia Island in the Indian Ocean. EPAC hopes to start space transportation services in 1996-97. It is making an official request to the US Department of Transportation for four launches during this period.

EPAC founder and President Bob Davis has this to say about the start of EPAC launch services:

"We look forward to finalising the terms of our first launch contract. Norris Satellite Communications Inc. is looking for a low-cost launch of Norstar-1, the first Ka-band high-capacity communications satellite for commercial services in North America. With this contract, our team will grow up to some 35 people. This first contract will represent two pioneering ventures in space business. EPAC is offering a revolutionary system for cheap space transportation services, while the Norstar system is developing another revolution with large-band highways for digital communications and broadcasts. We have contacts with a lot of potential customers, who would like to enter the business of applications satellites".

As a first phase of development, EPAC is proposing four models in the Eagle Series:

- Small two-solid stage Eagle with liquid upper stage to place up to 1,350 kg in a 360-km circular orbit. The third stage which is for orbital accuracy, is called Post Boost Vehicle (PBV) and is specially developed by EPAC.
- Large two-solid stge Eagle S-1 plus PBV to launch up to 2,700 kg in LEO or 1,500 kg in polar orbit (SSO) or 935 kg in GTO.
- Three-solid stage Eagle S-II plus PBV to put 4.5 tons in LEO or 2.5 tons in SSO.
- Three-solid stage plus restartable USTM (Unified Satellite Transfer Module) to put 4.5 tons in LEO or 2 tons in GTO. ■

Pegasus Launch

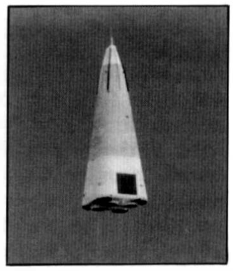
On 3 August a Pegasus rocket launched a USAF APEX satellite into orbit to study the effects of radiation and charged particles on the solar panels that power it. The rocket was launched from a B-52 aircraft at high altitude.

Recent problems with Pegasus rockets led the Air Force to postpone a series of satellite launches from Vandenberg Air Force Base. A Pegasus XL rocket, which is longer than the standard Pegasus, was destroyed by remote control three minutes after launch on 27 June because of a steering malfunction and other problems. Also lost was a 767-pound satellite carrying Air Force experiments. On 19 May a similar satellite was placed into a lower-than-planned orbit by a Pegasus booster.

Launch of Weather Satellite

On 29 August, an Atlas rocket carried into orbit an $84 million military weather satellite which is part of the Defense Meteorological Satellite Program. It will provide weather data for US military operations worldwide from a polar orbit at an altitude of more than 526 miles and will replace another satellite that is near the end of its 27-month operational lifespan.

DC-X Upgrade



McDonnell Douglas is to integrate key advanced technology components into the Delta Clipper-Experimental (DC-X) experimental reusable launch vehicle. The upgraded vehicle will be called the DC-XA. Agreements for this work have been signed by NASA Marshall Space Flight Center and McDonnell Douglas and are valued at approximately $43 million.

Beginning in April 1995, McDonnell Douglas will integrate company-designed and developed components, including a cryogenic liquid hydrogen tank, an intertank structure and elements of the gaseous oxygen and gaseous hydrogen reaction control system into the DC-XA. Additionally, a cryogenic liquid oxygen tank, made from an advanced Russian aluminum-lithium alloy, will be integrated into the vehicle.

In late 1995, McDonnell Douglas will transport the DC-XA to the White Sands Missile Range, N.M., for static hot fire and flight tests. It is anticipated flight tests will begin in mid-1996.

Under the agreements McDonnell Douglas will:

Develop two cryogenic propellant tanks, these being a graphite epoxy liquid hydrogen tank and the aluminum-lithium alloy tank noted above;

Design and build a graphite epoxy intertank structure for the DC-XA as well as a 25 percent operational-scale intertank structure for ground test purposes;

Develop a gasification unit to convert cryogenic hydrogen from liquid to gas form for use in the flight reaction control system;

Ground test a Russian-made filament-wound graphite isogrid intertank structure; and

Examine and test carbon-silicon carbide and other materials for a thermal protection system.

McDonnell Douglas developed the DC-X for the Ballistic Missile Defense Organization's Single-Stage Rocket Technology programme and recently returned the vehicle to Huntington Beach after completing five test flights at White Sands Missile Range.

Errata

***GOES-8*, by Roger C. Guillemette, *Spaceflight*, August 1994.**

p. 263, in second paragraph (column 1) for 'GOES-I' read 'GOES-8'.

p. 265, in third column for 'returned in July 1994' read 'successfully received on 9 May 1994.

Japan-Satellite in Wrong Orbit

Attempts to put a $415 million research satellite into its proper orbit were abandoned on 31 August after three tries without success to fire an on-board thruster. On the third attempt, a sluggish fuel valve stuck in the open position. The satellite, developed in Japan, was to have been used for experiments involving lasers and other advanced communications technologies. The loss is a setback for Japan's plans to enter the commercial satellite launching business.

The Kiku-VI satellite was carried into orbit on 28 August by the second Japanese-designed H-II rocket after two launch delays on one of which the H-II rocket boosters failed to ignite, leaving it on the launch pad. The introduction of Japan's H-II launcher has also suffered delays. It was originally scheduled for launch in 1991 but postponed until earlier this year because of engine development problems.

Optus B3 Launched

On 28 August, the Optus B3 communications satellite, built for Australia by Hughes Aircraft Co., was successfully launched aboard a Chinese Long March 2E and is reported to be functioning normally. It will provide telephone, data, television videoconferencing, mobile communications and air traffic control services across Australia and New Zealand.

This is the seventh successful launch of a Hughes spacecraft this year. Since it pioneered the business 31 years ago, Hughes has launched 108 communications satellites. More than half of the satellites operating around the world came from the Hughes Space and Communications Co. factory near Los Angeles.

The new satellite replaces Optus B2, which was destroyed during a December 1992 launch. Optus B1 was successfully launched on a Long March rocket in August 1992.

US Military Satellite Launched

On 27 August a Titan 4 rocket lifted a heavy Air Force satellite into space, giving Titan its ninth success in 10 launches and a third successful launch in a row.

Although details are classified, the rocket's second stage and its powerful hydrogen-fuelled Centaur third stage worked as planned, placing the satellite in an initial low-Earth parking orbit. Eight hours after launch, an Air Force statement said the rocket's payload had been successfully deployed "in the desired orbit," presumably after subsequent Centaur firings to boost its altitude. The classified payload is likely to be an electronic eavesdropping platform capable of tapping into military and civilian communications.

Martin Marietta holds contracts valued at $11.8 billion to build 41 Titan 4s to launch large national security payloads.

Astronaut News

Veteran astronaut ***Franklin Chang-Diaz***, 44, has been named payload commander for Space Shuttle mission STS-76, the second flight of the Tethered Satellite System (TSS) scheduled for early 1996. TSS was first flown in July/August 1992 as part of the STS-46 mission.

The Italian-built satellite is designed to orbit at the end of a 13-mile-long tether to test techniques for managing spacecraft at great distances and to study the electrodynamic effects of moving a conductive tether through the Earth's magnetic field.

Air Force Colonel ***Terence T. (Tom) Henricks*** will command Space Shuttle mission STS-70 scheduled for launch in mid-1995 carrying a Tracking and Data Relay Satellite (TDRS-G) used as part of a three-satellite telecommunications system to meet the needs of Space Shuttle and low-Earth orbit spacecraft missions. Joining Henricks on the five-day mission are ***Kevin R. Kregel*** pilot; Army Major ***Nancy Sherlock***, mission specialist; ***Donald A. Thomas***, Ph.D., mission specialist and ***Mary Ellen Weber***, Ph.D., mission specialist.

Air Force Col. ***Richard Covey***, the commander of the Hubble Space Telescope repair mission, is leaving NASA after 16 years as an astronaut. Covey, 47, made four shuttle flights. He will become director of business development in Houston for Calspan Services Contracts Division, an operating unit of Space Industries International Inc.

'Shuttle Dimensions' Competition

The Space Shuttle Orbiter is described in a NASA information leaflet as 'about the size and general shape of a DC-9 commercial jet airplane'. Close-up photos of it, such as that on p.333 and the front cover, leave no doubt about its size. This month's competition focusses on the dimensions of the Shuttle system including the External Tank and Solid Rocket Boosters with eight questions to enable for readers to size things up and perhaps win a prize.

Prizes: The first five correct entries to be opened after the closing date of 3 November 1994 will receive a copy of the compact disc:

Apollo 11 Moon Landing: The BBC Television Broadcasts July 16-24 1969

To Enter: Supply the following eight dimensions from the list below:

1. Orbiter length ....
2. Orbiter wingspan ....
3. Payload Bay width ....
4. Payload Bay length ....
5. External Tank length ....
6. External Tank diameter ....
7. Solid Rocket Booster length ....
8. Solid Rocket Booster diameter ....

List of dimensions in metres: 3.7 4.6 8.7 18.3 23.8 37.2 45.4 46.9

About this month's prize

Relive the Events of the Apollo 11 Moon Landing with 73 minutes 36 seconds total playing time of live studio broadcasts from BBC Television coverage, 16-24 July 1969, including:

• Introduction: Arthur C. Clarke; • Launch from Cape Kennedy, Florida: 16 July 1969; • Lunar Landing: 20 July 1969; • On the Lunar Surface; • Lift off from the Moon; • Splashdown in the Pacific, and Recovery: 24 July 1969 • Postscript: Patrick Moore.

Available from all record stores in the UK and US (Pearl: GEMM CD 9136)

Title/Name ....

Address ....

....

....

Post to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England To arrive by first delivery on 3 November 1994.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

Tense Week for Mir

After the Progress M-24 ferry twice failed to dock automatically on 27 and 30 August, it was third time lucky on 2 September, not only for the present Mir crew but also for the future of the Russian manned space programme.

Much rested in the hands of Yuri Malenchenko, the mission commander, who guided the Progress manually by remote control to a successful docking, using images transmitted by it to his command module on Mir.

Launch Sites for Russia

The funding and the 16,000-strong operational personnel of the Baikonur Cosmodrome and the residental town of Leninsk are to be removed from the Russian Defence Ministry's structure and transferred to the Russian Space Agency, but they will remain subordinate to the military space forces. This arrangement has already been agreed upon with the Kazakhs and makes an agreement possible on the leasing of the cosmodrome to Russia by early October.

Yuri Koptev, Director General of the Russian Space Agency said that Government Presidium members had also discussed the possibility of converting into a cosmodrome the former strategic missile base of Svobodny-18, near the Amur river (Central Siberia). The first launch is expected in 1996 with a Russian ICBM carrying a payload into low orbit. The existing infrastructure of the Svobodny-18 facility will be used as the main centre for testing and utilising space hardware. Five remaining silos - 55 silos were destroyed - will be gradually implemented to achieve low-cost operations in space.

The Svobodny-18 launch site is not suitable for launching Soyuz, Zenit and Proton vehicles. A total of 4000 to 4500 billion roubles (at present prices) would be needed to convert the existing infrastructure into a new and modern multipurpose cosmodrome and it would take 10-12 years to complete the work. A decision about the future for the Svobodny region will be submitted to the Russian authorities on 1 November.

Russia has another, more urgent, plan which is to upgrade and extend the Plesetsk cosmodrome. Yuri Koptev pointed out however that for manned space operations, the use of Baikonur would continue into the immediate future.

Atlas Launch

On 3 August an Atlas IIA rocket successfully launched the direct broadcast satellite-2 (DBS-2) of DIRECTV(TM) Inc. from Launch Complex 36A at Cape Canaveral. It was the third successful Atlas launch this year, the 515th Atlas launch overall and the 83rd flight for Atlas with Centaur.

Last February, DIRECTV(TM) Inc. a unit of GM Hughes Electronics, selected Atlas to launch DBS-2, when a USAF Medium Launch Vehicle mission originally scheduled for July moved to 1995. DIRECTV's two-satellite DBS constellation will become operational this autumn, delivering up to 150 channels of TV entertainment to homes possessing the Digital Satellite System (DSS(TM)) receiving hardware.

DBS-2 also carred the SpaceArc(R) time capsule which was developed as a non-profit educational project by the Rochester Museum & Science Center in Rochester, N.Y. SpacArc(R) includes messages from 38,000 participants who have contributed their thoughts, hopes, dreams, and images of our civilization for future generations.

South African Microsatellite

NASA has agreed to launch Sunsat, South Africa's first satellite, which is a 50 kg microsatellite developed at Stellenbosch University near Cape Town, in January 1996.

A four-member NASA team evaluated the Stellenbosch project and offered the university a free launch in return for minor additions of American equipment.

Sunsat will send back high-resolution images of the Earth in three colours and will be able to return images from the other side of the Earth stored in its memory. It will carry amateur radio equipment that would be used to stimulate technical interest among schoolchildren by enabling children to talk to the satellite in space.

NASA was keen to launch Sunsat because it could carry a Global Positioning System (GPS) receiver and a laser reflector needed to monitor variations in the Earth's gravitational field. The satellite will be controlled from the university during its expected four-year life. (See *Spaceflight*, October 1993, p.341).

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
1994					
STS-68	2 October	Endeavour	9 Days	SRL-2	57.0
STS-66	Late October	Atlantis	10 Days	Atlas-3, Crista-SPAS, SSBUV/A	57.0
1995					
STS-67	January	Endeavour	13 Days	ASTRO-2	28.5
STS-63	February	Discovery	8 Days	Spacehab-3, Spartan-204, CGP/Oderacs-2	51.6
STS-69	May	Endeavour	10 Days	Spartan, WSF	28.5
STS-71	May	Atlantis	9+1 Days	Mir-01 Mission	51.6
STS-70	July	Discovery	5 Days	TDRS-G	28.5

First Malaysian Satellite

MEASAT-1 is the first satellite of the Malaysian space telecommunications programme and Binariang SDN BHD has chosen Ariane for its launch at the end of 1995.

Built by Hughes Aircraft Company, it uses the HS 376 platform and will weigh under 1400 kg although it carries 10 C band and 4 Ku band transponders. It will provide telecommunications services for telephone, telex, data transmission and direct digital TV broadcasting for Malaysia, the Philippines and the south of the Indian peninsula.

STS-65 Mission Report

BY ROELOF SCHUILING
at The Kennedy Space Center

The crew at breakfast prior to suitup and departure for the launch pad. From left are Chiaki Mukai, Carl E. Walz, James D. Halsell, Jr., Robert D. Cabana, Richard J. Hieb, Leroy Chiao and Donald A. Thomas. NASA

Longest Flight of the Space Shuttle Program

International Microgravity Laboratory-2 Demonstrates Telescience

Columbia returned to Earth on 23 July after surpassing the previous flight duration record of STS-58 which was also a Columbia mission. The scheduled landing was extended one day due to uncooperative weather at the Kennedy Space Center's landing site on 22 July.

As the STS-65 astronauts orbited the Earth, the 25th anniversary of the landing of the Apollo 11 on the surface of the Moon was taking place. The Apollo 11 crew also flew in a spacecraft named "Columbia".

Flight Day One

The "red team", which was made up of Bob Cabana, Jim Halsell, Rick Hieb and Chiaki Mukai, powered up the International Microgravity Laboratory-2 (IML-2) Spacelab and checked the equipment.

The "blue team" of Carl Walz, Don Thomas and Leroy Chiao began the first shift of operational research. The IML-2's Critical Point Facility was also powered up and Earthbound experimenters were able to watch their experiments in action on ground television screens as they were operated.

Flight Day Two

The crew continued their round-the-clock working shifts and the orbiter continued to perform well. The Shuttle amateur radio system called SAREX was activated. Later it was used to talk to students on the ground during the mission.

Don Thomas completed one of two Biorack experiments that studied the production of cytokines which are proteins that prompt immune cells to multiply. Previous microgravity experimentation indicated that the absence of gravity reduced immune cell production.

A problem developed with the data downlink from the Real-Time Radiation Monitoring Device which measures cosmic radiation entering the IML-2 module. The device was turned off as ground personnel analysed the situation and prepared an inflight maintenance procedure.

Flight Day Three

Rick Hieb was able to reestablish the information downlink from the Real-Time Radiation Monitoring Device by re-adjusting the communications cable. This allowed the experiment's information to be transmitted to ground stations for the first time during a mission. This information was also transmitted to remote Earth sites for comparison with similar observations. The IML-2 device is the first step toward the creation of a space environment forecasting system that may eventually be able to warn astronauts of radiation storms.

Chiaki Mukai reported that the Medaka fish had become more active, but continued to appear disoriented in microgravity. She counted 10 Medaka eggs in the aquarium and gave the fish their first scheduled feeding.

The mission's first Critical Point Facility experiment which studied how a liquid stabilised and reached equilibrium drew to a close after 43 hours of operation. Similar studies were conducted on Spacelabs D-1 and D-2. However on IML-2 the experiment appeared to take longer to reach stabilisation so controllers gave the experiment more time for these studies to be continued.

Flight Day Four

Although operations were proving more difficult than anticipated, ground experimenters using the TEMPUS containerless processing facility were getting good data in a number of areas - including the measurement of the specific heat of a liquid metal.

Don Thomas reported that the fish appeared to continue to be in good health and injected female newts with a substance designed to induce them to lay eggs in the microgravity environment. The eggs will be studied after landing to determine the effects of microgravity on development.

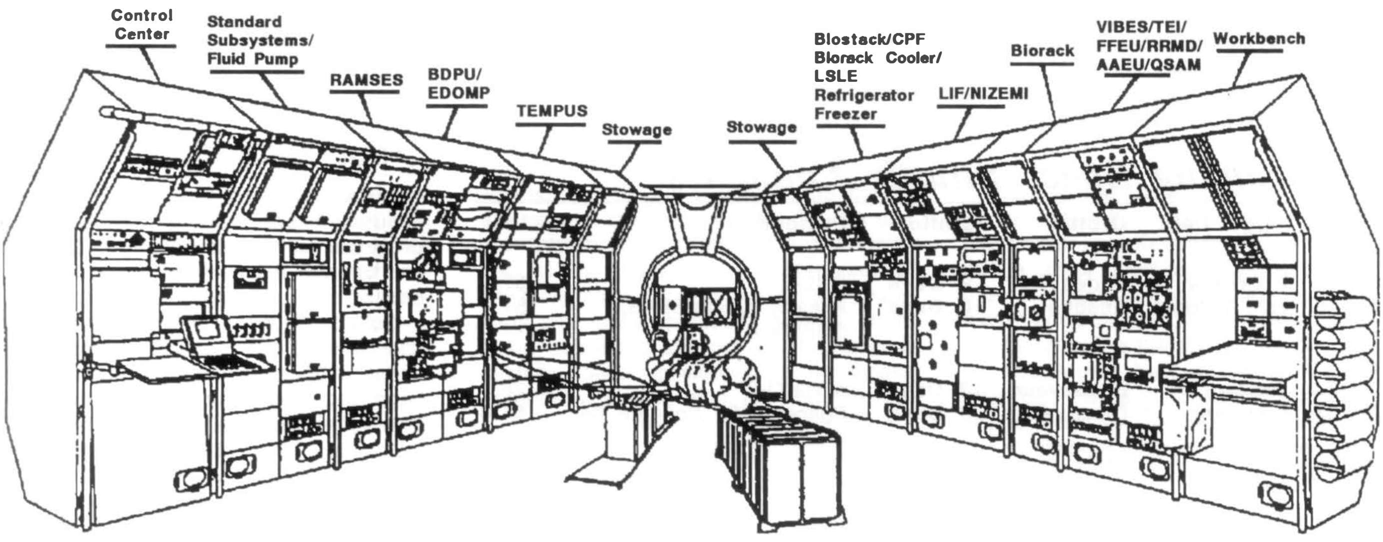
Following his daily height measurement for the Canadian Spinal Changes in Microgravity experiment, Rick Hieb joked that he had become too tall to be an astronaut in growing an inch. Astronaut height limitations are six feet four inches.

Flight Day Five

Columbia continued to perform well. The Spacelab module was reporting an erratic tape recorder performance; however four recorders were available to record the necessary data.

Don Thomas reported the first hatching of one of the newt eggs and, later in the day, Mukai reported the first new Medaka

IML-2 module racks. LSLE = Life Sciences Laboratory Equipment; other acronyms are explained on p. 341. NASA



fish in the aquarium.

Hieb worked with the fruit flies in a study of aging. Fruit flies have relatively short life spans and are, therefore, useful in that a major portion of their entire life cycle can take place during a Shuttle mission. The results of the aging studies will be used in supporting studies of human aging.

Japan's first woman astronaut Payload Specialist Chiaki Mukai, MD, PhD, greets the press on her way to the Astro Van awaiting to take the crew to launch pad 39A. The one-time Keio University Hospital chief resident in cardiovascular surgery was selected by the National Space Development Agency of Japan in 1985 to be one of three Japanese astronauts. Although stricken by space sickness for the first two days, Dr Mukai bounced back to recover and exceeded her assigned tasks on the IML-2 mission.
PETER GUALTIERI, WEST KENTUCKY NEWS

Mukai was active in studies of rodent bone cells in support of studies which may lead to a better understanding of osteoporosis in humans.

In the materials sciences field, the crew sent video images of experiments in the Critical Point Facility down to researchers in The Netherlands.

Chiaki Mukai readied ESA's Bubble, Drop and Particle Unit (BDPU) for its first activation. The BDPU studies behaviours such as bubble formation, evaporation, condensation and flows due to temperature differences. Such phenomena are very difficult to study on Earth as their effects are masked by gravity.

Flight Day Six

The IML-2 experiments continued to occupy most of the crew's time.

Don Thomas supported ground-based experimenters in studies using the Critical Point Facility, and with the BDPU experimental facility in studies of fluid layers, evaporation and condensation and made adjustments to the TEMPUS containerless facility in cooperation with ground-based experimenters.

Chiaki Mukai and Rick Hieb got a half day off today, but telescience operations continued as ground experimenters made observations and recorded data from the experiments.

At T+46 s and at approximately 20,000 ft and 200 mph, with engines at two-thirds throttle, STS-65 is 10 s into max Q, where the air pressure is greatest during ascent. The shock waves coming off the rocket condense the moisture in the atmosphere creating the "God of Speed" effect. Thirteen seconds later a cloud of condensation flashed briefly as the rocket passed an unusually moist layer of air.
PETER GUALTIERI, WEST KENTUCKY NEWS

Flight Day Seven

By now the Spacelab Mission Opera-

Telescience Operations for European Experimenters

An important emphasis of the IML-2 mission was the demonstration of telescience - or remote operations. ESA is keen to support this area of science as it will take on great significance when the International Space Station becomes operational.

The Telescience operations on IML-2 were not another series of experiments or technology demonstrations, but very much a service to scientists. Scientists and engineers in Europe had the opportunity to participate actively during the operations of the experiments.

Such direct participation, where commands can be issued from User Centres, means that modifications and changes in schedules can be made in real-time as the experiment is taking place, or based on immediate results.

Another significant advantage is that experimental data can be received directly at the laboratory or institute, giving the scientists immediate access to the data for evaluation and reaction.

These kind of interactive remote operations have been exercised before by ESA during sounding rocket flights from Italy at MARS and previous Spacelab flights, such as D2 from Germany at MUSC, ATLAS-1 from The Netherlands at ESTEC and ATLAS-2 from Belgium at IRMB.

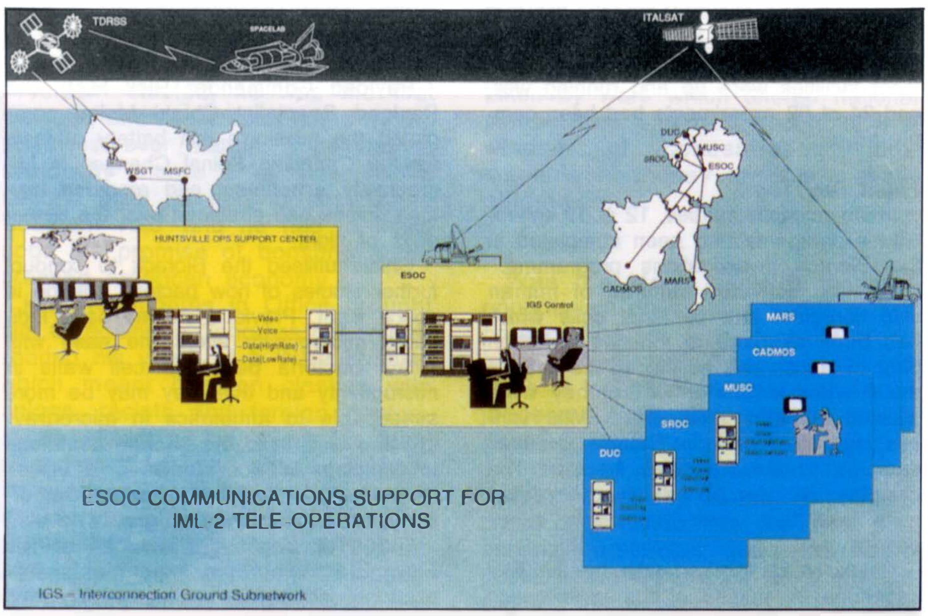
Communications were based on the Interconnection Ground Sub-network (IGS) which connected the remote sites to NASA's Huntsville Operations Support Center (HOSC).

At ESOC an integrated Network Management Facility monitored and controlled the services for all sites. It acted as a communications hub, linking the NASA Payload Operations Control Centre (POCC) at the MSFC in Huntsville to the European User Centres:

- MUSC, Cologne controlled three facilities - the Critical Point Facility (ESA) and the TEMPUS and NIZEMA facilities (both DARA).
- MARS, Naples, Italy, controlled and carried out an experiment with the ESA Bubble, Drop and Particle Unit (BDPU).
- DUC, Amsterdam monitored an experiment on the CPF.
- SROC/ULB, Brussels, controlled an experiment on the BDPU.
- Cadmos, Toulouse, accepted responsibility for the CNES (France) RAMSES facility.

During the IML-2 mission the Principal Investigator for each experiment was stationed at the POCC in Huntsville. Support teams lead by the Co-investigator were located at the remote User Centres.

Based on an edited version of 'IML-2', published by ESA Public Relations, July 1994.



Right: **Communication support for the IML-2 mission. The Network Control Centre at ESOC provides all connections between HOSC and the five remote centres in Europe.** **ESA**

tions Control Center had issued more commands to the IML-2 payload experiments that it had on any previous mission. The record had been 12,081 commands to ASTRO-1 during its November 1990 mission. The capability to issue commands to experiments from the ground allows the scientists involved to make the most effective use of the time in space.

Mukai reported 15 fish in the aquarium which had been hatched in space and she said the remaining three newts were doing well. Hieb reported that the fruit fly specimens seemed to be doing more crawling that flying in the microgravity environment.

The BDPU and TEMPUS facilities continued studies in the material sciences area. The BDPU facility performed studies of how heat can control migration of bubbles in liquids and TEMPUS studied heat capacity in a zirconium-nickel alloy.

Flight Day Eight

The crew continued their use of the SAREX amateur radio system to speak with schools.

In a fluid science experiment, Don Thomas installed a test container in the BDPU facility in order to study the prevention of flaws in metals and alloys produced in microgravity.

With the TEMPUS containerless processing facility the solidification of quasicrystals (structures with 20 triangular facets) and the heat capacity, viscosity, and surface tension of a metallic glass alloy were investigated.

The TEMPUS unit was used to melt a zirconium-nickel sphere which was then electromechanically squeezed to start oscillations whose frequency was measured in a study of the surface tension and viscosity of the liquid metal.

Flight Day Nine

During the morning Robert Cabana changed experiment containers in the Critical Point Facility to begin a 77 hour experiment to determine how such factors as heating or change of pressure affect a fluid near its critical point.

Payload Specialist Mukai reported there were now about 20 Medaka fish that had hatched in the IML-2's aquarium.

At this point in the flight 18 of 19 experiment facilities were up and running well, and 24 of 82 experiments had been completed.

Flight Day Ten

In life sciences studies, 12 of 19 scheduled experiments had been completed in the Biorack investigations programme.

Thomas activated cultures of human skin fibroblast and bacterial cells which had been exposed to ionizing radiation prior to launch and he placed the cells in the Biorack incubator where they were allowed to repair themselves. After various incubation periods Thomas removed samples to the Spacelab freezer. The samples will later be examined to determine how they repair themselves in microgravity.

Chiaki Mukai worked with the NIZEMI centrifuge in studies of the solidification of a two-component material which mimics alloy behaviour.

TEMPUS operations included the suspension of orbiter attitude thruster firings during short periods of the day's experimentation in order to provide an extremely stable environment for the facility's operations.

Flight Day Eleven

During the morning one of Columbia's small vernier thrusting jets failed; however it was recovered later after ground controllers determined the problem was a clogged transducer. The jet is one of six used to fine-tune the spacecraft's attitude.

Observations of the Aquatic Animal Experiment Unit showed that a second female newt had died. The newt had produced eggs earlier in the mission. Observations of the young Medaka fish which had been hatched on the flight were video linked to experimenters on the ground.

Don Thomas injected concentrated solutions of DNA into the Free Flow Electrophoresis Unit in a study of chromosome separation which was being tested in space as an aid to solving problems of genetic mapping. Later, Payload Specialist Mukai was working with the unit in a study of growth hormone activity when she found that the cells from the bottom of the container had come loose and were clumping together which had not happened on Earth.

Flight Day Twelve

One of Columbia's three inertial measurement units (IMU) began sending a series of error messages. Although still functioning well and capable of providing data for landing, the IMU was under analysis by ground controllers. The inertial measurement unit is one of three such units on Columbia. Ground controllers compared the IMU to another aboard Columbia and determined the unit was still healthy.

During his shift Don Thomas reported that the remaining newts, including those hatched on the mission, appeared to be doing well.

The NIZEMI centrifuge was used to expose plant specimens to a one-tenth gravity field in the continuing study of varying gravity levels.

Payload Commander Rick Hieb and Payload Specialist Chiaki Mukai completed the mission's last battery of tests for the Canadian Spinal Changes in Microgravity experiment and recorded how their spines had stretched over the twelve days of flight.

Chiaki utilised the Biorack to conduct further studies of how bacteria change in space flight. Previous studies have indicated microgravity alters the ease with which bacteria penetrate cell walls in microgravity and that they may be more susceptible to antibiotics in microgravity. She also used the NIZEMI centrifuge to complete mission studies of a unicellular organism designed to show how organisms react to varying gravity levels.

Rick Hieb began the last of the Free Flow Electrophoresis experiments' operations, separating cellular secretions from animal cells into individual components. A new procedure is being used on Earth which provides a faster growth of cancer diagnosis antibodies but the procedure for separating the useful substances from the culture medium is complicated and inefficient and the separation techniques being studied in space may provide better results.

Flight Day Thirteen

Two more Biorack experiment operations were completed when Don Thomas and Leroy Chiao injected containers of bacteria with substances to halt their growth for later study and they used a salt solution to increase osmotic pressure in support of an investigation on the effects of space flight on bacterial specimens. Chiao also extracted samples of yeast growing in microgravity and studied radiation exposed bacteria cells undergoing centrifuge as well as static conditions.

Payload Specialist Mukai told ground experimenters that she saw a hatched Medaka fry in the aquarium. The fry came from an egg laid during the mission as compared to the hatched fry from eggs fertilised on the ground which had hatched earlier in the mission.

Flight Day Fourteen

Cabana and Halsell began preparing for the then-scheduled next day's landing by testing the systems that would take them through reentry and landing. Later in the day the crew began stowing science experiments and shuttle equipment in preparation for landing. The final two Biorack experiments were studies of gravitational sensing in plants and sea urchins. Don Thomas deactivated the IML-2 Real-Time Radiation Monitor and used a hand held sampler to collect data on contamination levels in the Spacelab. Preparations continued to deactivate experiments in preparation for the next morning's scheduled landing of Columbia.

Flight Day Fifteen

Weather at the Kennedy Space Center proved an obstacle to landing as scheduled. A rain storm off the coast of the space center violated landing weather rules and the mission's managers elected to postpone the landing until the following day.

The landing delay resulted in the crew of STS-65 surpassing the record for longest duration Shuttle flight, which had previously been held by STS-58's November 1993, 14 day 13 minute mission.

Flight Day Sixteen

The Florida weather cooperated and Columbia reentered the Earth's atmosphere and headed for the KSC landing strip early on the morning of 23 July. It landed on orbit 236 after travelling approximately 6,143,000 miles. The landing came at about 6:38 am local time on KSC's runway 33. The mission duration was 14 days, 17 hours and 55 minutes. Main gear touchdown came at 6:38:01 am with nose gear touchdown 17 seconds later and wheel stop at 6:39:09 am.

About the Payload

IML-2 involved scientists not only from the United States, but also from ESA and the national space agencies of Canada, Germany, France and Japan. Whereas materials science studies tend to draw heavily on spacecraft power, life science studies draw more heavily on crew time.

Life science studies included the following:

The Aquatic Animal Experiment Unit (AAEU) provides life support for newts and fish. The spawning, fertilisation, embryology and behaviour of these animals in microgravity is studied. The experiment included two inner packages which were the aquarium package and the fish package. Several pairs of male and female Medaka, a small freshwater fish found in Japan's ponds and rivers, were placed in the unit prior to launch. Japanese red-bellied newts were also studied. These studies not only provide information on the development of aquatic animals but may also point the way towards development of food production for long space voyages.

The Biorack is a multipurpose facility supporting investigations into 18 areas of life studies on the effects of microgravity and cosmic radiation on tissues, plants, bacteria and other biological samples. The Biorack system contains incubators and a glove box.

The Biostack experiment is a passive set of layers of biological samples placed between various types of sealed detectors to measure the effects of cosmic radiation on biological samples.

The Extended Duration Orbiter Medical Project (EDOMP) experiments consist of the Lower Body Negative Pressure Device (LBNPD) which has flown on a number of previous Shuttle missions and the Microbial Air Sampler (MAS) which collects airborne cabin microbial contaminants for post-flight study to determine the possible risks to crew health and safety.

The Performance Assessment Workstation was developed to evaluate the effects of microgravity and the stresses of spaceflight upon the cognitive skills of space crews.

The Real Time Radiation Monitoring Device (RRMD) measures the high energy radiation entering the IML-2 and recorded impacts on biological materials.

The Slow Rotating Centrifuge Microscope (NIZEMI) experiment contains a microscope and macroscope to monitor the movement and behaviour of small organisms and samples of materials in a 10^{-3} to 1.5 g gravity field. The living matter samples included protozoa, plant and animal tissue cells, and fungi and the non-living material included protein and other crystals and chemical compounds.

The Spinal Changes In Microgravity experiment records changes in astronauts' spinal columns using stereophotography and ultrasound.

The Thermoelectric Incubator (TEI) was a general purpose incubator used in the IML-2 to maintain plant and animal cultures at a temperature of 37 degrees C. Petri dish chambers were used in support of slime mould and plant cell studies together with animal cell culture kits with transparent windows for observation and photography.

Microgravity science studies included the following:

The Advanced Protein Crystallisation Facility provides a versatile environment for growing protein crystals using three different techniques to produce more uniform crystals than can be grown in the one-gravity environment of Earth.

Applied Research on Separation Methods Using Electrophoresis (RAMSES) investigates the use of forces imposed on a charged body by an electric field to separate molecular material in a liquid. Microgravity conditions minimise the effects of thermally driven convection on materials separation studies.

The Bubble, Drop and Particle Unit (BDPU) studies the dynamics of bubbles, drops and particles within optically transparent fluid matrices in a microgravity environment by using special optical, camera and sensor methods.

The Critical Point Facility (CPF) enables investigations to take place with respect to materials transitioning from liquid to gaseous states. The studies are much more reliable in microgravity as the tendency of fluids to compress under their own weight is eliminated.

The Electromagnetic Containerless Processing Facility (TEMPUS) provides a levitation melting facility for processing metallic samples in an ultraclean microgravity environment. Samples are kept from touching the container wall by an RF coil system contained in an ultrahigh vacuum processing chamber.

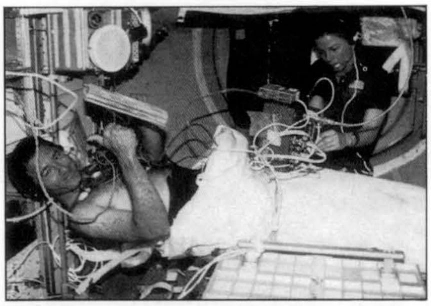
The Free Flow Electrophoresis Unit (FFEU) uses an electric field to separate biomaterials, however, it dealt with a different set of biomaterial samples than RAMSES.

The Large Isothermal Furnace Facility (LIF) uses the microgravity conditions of space flight to melt, uniformly mix and solidify compounds.

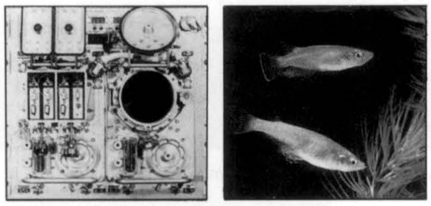
The Quasi-Steady Acceleration Measurement System (QSAM) and ***The Space Acceleration Measurement System*** sensors measure low frequency acceleration components and accelerations caused by crew movement and orbiter motions. ***The Vibration Isolation Box Experiment System (VIBES)*** also measures crew motion accelerations.

An additional experiment flying in the middeck area was the ***Commercial Protein Crystal Growth*** experiment containing refrigerator/incubator units for growing crystals in microgravity. This unit with its samples was installed at the launch pad one day prior to launch.

Life Sciences



EDOMP: Extended Duration Orbiter Medical Poject developed by NASA. NASA

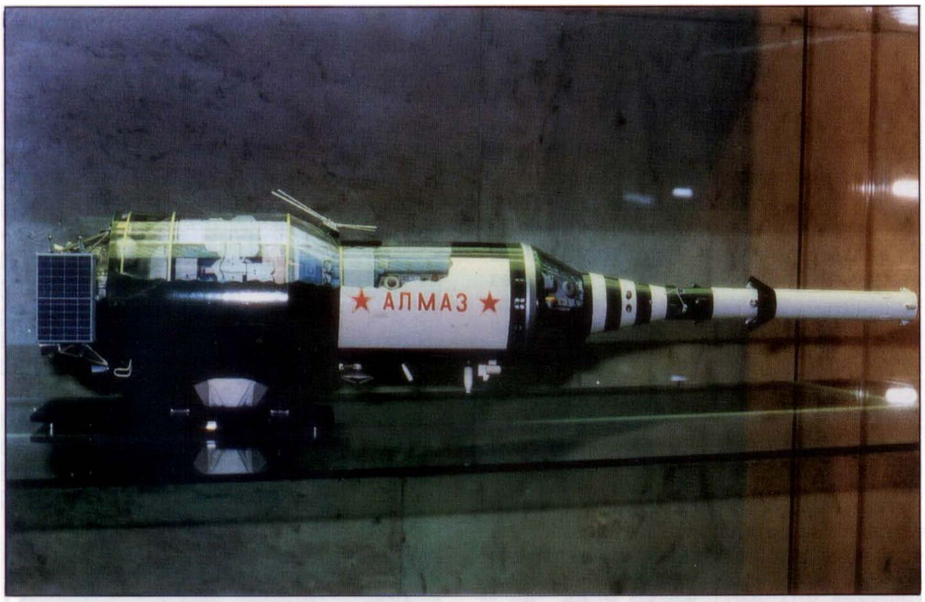


Left: **AAEU (Aquatic Animal Experiment Unit) hardware developed by NASDA.** *Right:* **Medaka fish in the AAEU observed for microgravity effects.** NASA

Microgravity Science Studies

Ulf Merbold monitors the CPF (Critical Point Facility) during IML-1. These experiments, extended by IML-2, were developed by ESA. NASA

The CPF imagery is sent directly to the ground control center at MSFC, where scientists can analyse it. If they want to change experiment parameters, such as temperature, investigators can command the CPF directly from their consoles in the control center. NASA



A side view of the Almaz station. (All photos: © D. HAESELER 1994)

BY DIETRICH HAESELER
Taufkirchen, Germany

Original Almaz Space Station
Design on Display in Exhibition

In honour of the 80th birthday of chief designer Vladimir Nikolayevich Chelomei (30 June 1914 - 8 December 1984) an exhibition was opened at the end of June in the Memorial Museum of Cosmonautics in Moscow. Beside several personal belongings and documents of Chelomei, items from the manned missions to the Salyut space stations Salyut 1, 3 and 5 were on display. These stations were adapted from the original design of a purpose-built military station named Almaz, which has been already described in the March issue of *Spaceflight* [1].

The original station project incorporated two vehicles: the station Almaz itself and a crew and cargo transport spacecraft named TKS. Both vehicles included a recoverable capsule named Merkur. Small models with cutaways to show the interior were presented in this exhibition and are shown in the accompanying photos taken by the author.

Almaz Space Station

The station is described first. One Merkur capsule with its launch escape tower is shown mounted on the station on the right of the photo above. This configuration is for launch on top of a Proton rocket. One of two solar arrays is shown folded at the left of the photo and a docking system is located behind it for docking the TKS to Almaz. The white feature at the underside of the large cylinder is the opening of a large telescope complex.

The section that has white stripes, contains the engines for attitude control and deorbit as well as parachutes. The escape system tower obviously contains two independent engine systems, the main thrusters which are shrouded in the centre of the tower, and smaller secondary engines which are at the top of the tower. While the main thrusters serve for high-acceleration separation of the capsule with the crew from a malfunctioning launcher, the secondary thrusters may serve for attitude control during an emergency and for extraction of the tower after a certain height has been achieved and the tower is no more needed. Small openings in the ring at the base of the Merkur capsule house thrusters for attitude control of the Almaz station.

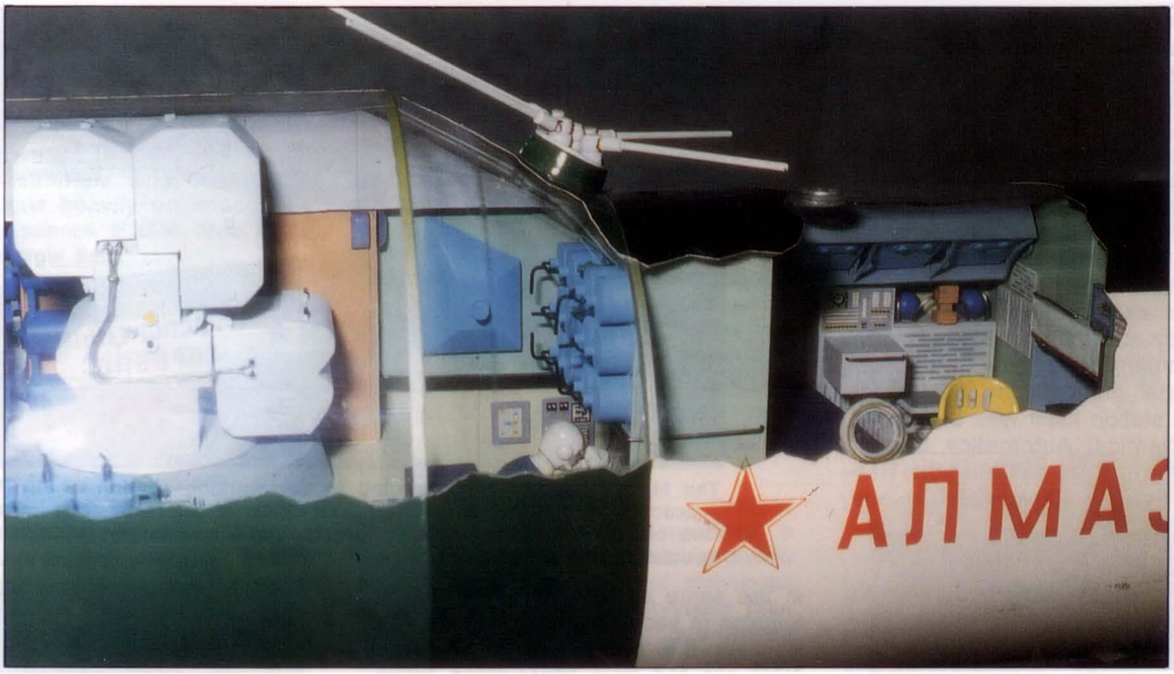
Two of three cosmonaut couches with seat belts are seen in the cutaway section of the Merkur capsule. Photos of the inside of this type of capsule have already been published in references 2 and 3. Openings of attitude control thrusters can be seen to the right as well as several antennas.

The Almaz living section contains a small table used to prepare the meals, and a yellow seat is near a window for observing the Earth. The cosmonauts sleep here, too. This living section is separated from the command section by a storage of 12 blue cylinders which most probably contain air supplies for the crew. Below the cylinders a cosmonaut can be seen working at a large panorama-telescope.

A large photographic telescope occupies the large cylinder behind the command section. It was planned to develop the films aboard and to transmit the most important photos via a TV-channel to the ground. Silver spheres contain propellant for attitude control. Power is supplied by two large solar cell arrays, one of which is folded towards the rear section of the station. Struts above and below each folded panel obviously carry the launch vehicle adapter.

The docking system is used to dock the TKS spacecraft. The two solar cell arrays are folded beside it, surrounded by struts to carry the Proton launch vehicle adapter to provide clearance for a clean separation. The adapter slides on rolling balls on the top of each strut. Two large orbit manoeuvring thrusters with 3900 N thrust can be seen. Propellant is contained in the silver spherical tanks, while smaller black tanks contain the pressurisation gas for the propellant feeding system. On top behind the docking system is a hatch for exit into open space to perform spacewalks. Hardly visible is the hatch below the docking system to release a small automated capsule to return films etc to Earth.

A view into the Merkur capsule.



The living section in the smaller cylinder of the Almaz station.

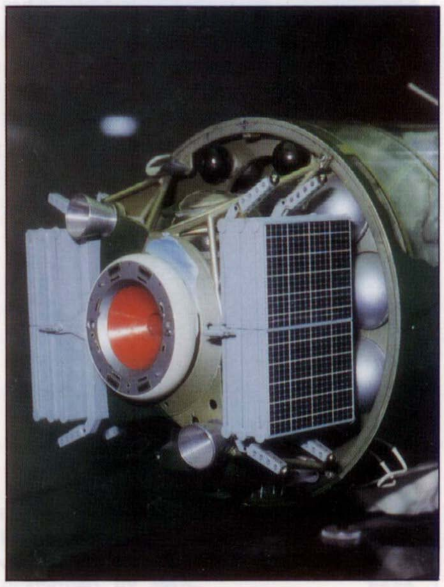
TKS Spacecraft

Crew and cargo were to be transported to this station using the TKS spacecraft, which was developed in parallel to the station by the Chelomei design bureau. The TKS, which is shown in the photo below, consists of a working section on the right of the photo connected to a Merkur return capsule and an emergency escape system on the left. One of two solar arrays is shown folded towards the smaller cylinder of the working section. This spacecraft is docked to the right to the Almaz space station as shown in the photo at the top of the opposite page.

The TKS without the recoverable Merkur capsule is very similar to the FGB "space tug" proposed for the International Space Station by the Salyut design bureau, the organisation which succeeded the Chelomei design bureau.

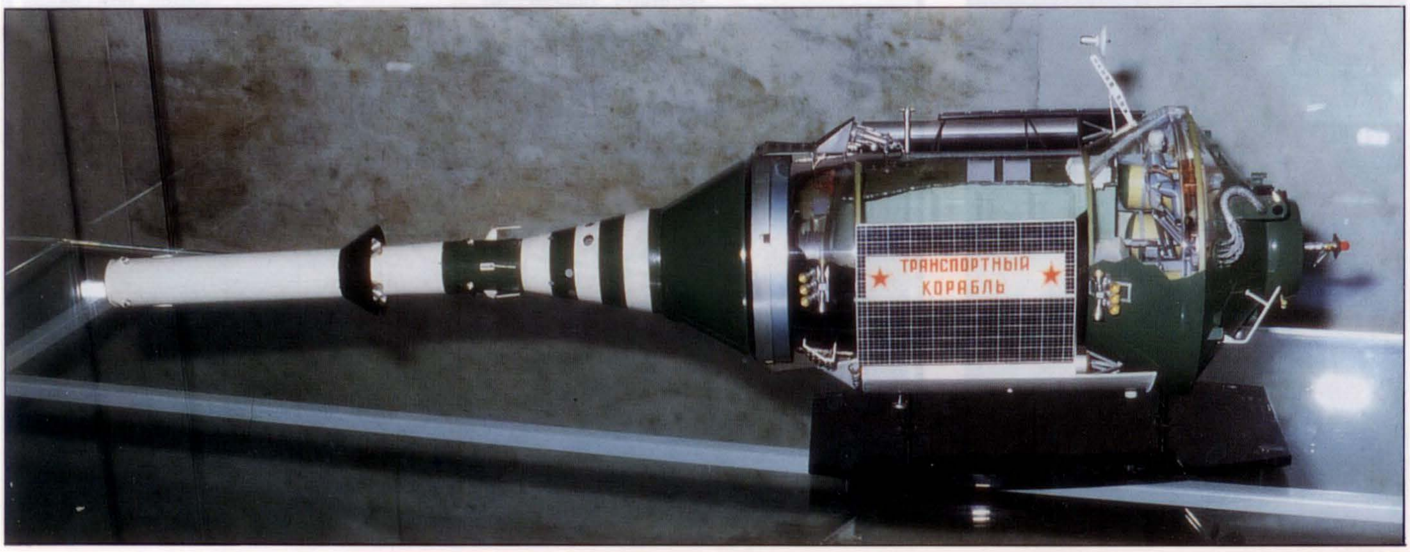
The interior of the TKS working section contains a lot of storage and two cosmonaut seats mounted with a girder structure between two tracks. These tracks run along the length the working section cabin, but the seat arrangement shown would not fit inside the smaller cylinder with a diameter of 2.9 metre. The seats are equipped with brown belts to fix the torso and the feet in weightlessness. The hatch of the docking system to Almaz is on the right. Two sets of five attitude control thrusters are mounted near both ends of the working section.

The position of the cosmonauts allows them to look through two window above the docking collar when docking with the Almaz station. The active docking system is on the right, while the rendezvous radar is extended on top of the cabin. White handrails for spacewalks can be seen in this area on the docking unit but the features with cable bundles are currently unexplained.



Docking system at the rear of the Almaz station.

TKS spacecraft connected to a Merkur return capsule.



Manoeuvring Engines

The manoeuvring engines of the TKS spacecraft generate 400 kg of thrust and were developed by the Chemical Automatics Design Bureau (KB KhimAvtomatiki, the descendant of KB Kosberg), while the smaller attitude control thrusters of TKS with 40 kg thrust were developed byt he Chemical Machines Design Bureau (KB KhimMash, the Isayev). Both engines were exhibited beside the models of Almaz and TKS and are shown in the accompanying photos.

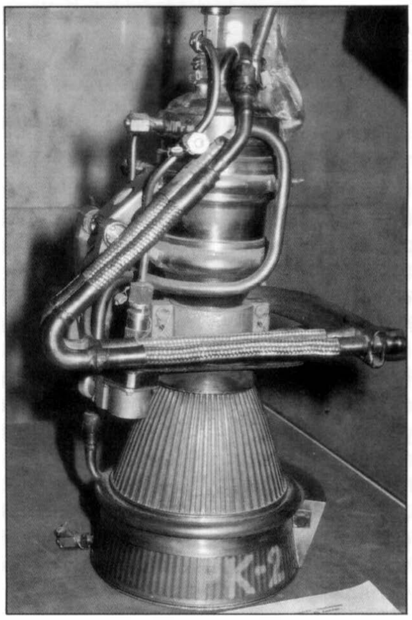
The orbital manoeuvring engine for the Almaz station itself was developed by the Chemical Automatics Design Bureau under the designation RD-0225. The thrust is 400 kg (3900 N) and is the same as for TKS. The specific impulse in vacuum is 291 s (2854 N.s/kg). As the propellants UDMH and NTO are fed from pressurised tanks, the chamber pressure is only 8.8 bar, typical for this kind of propulsion system. The photo shows the RD-0225 engine with its nozzle of area ratio 64.

The Merkur capsule is connected to the working section of the TKS spacecraft via a tunnel through the heat shield of the recoverable capsule. One cluster of attitude control thrusters and one larger manoeuvring thruster can be seen on top.

The unified attitude control and manoeuvring propulsion system of Soyuz-T and Soyuz-TM, as well as for Salyut and Mir were all developed by the Chemical Machines Design Bureau. No engine of the Chemical Automatics Design Bureau is known to have been used with these spacecraft.

References

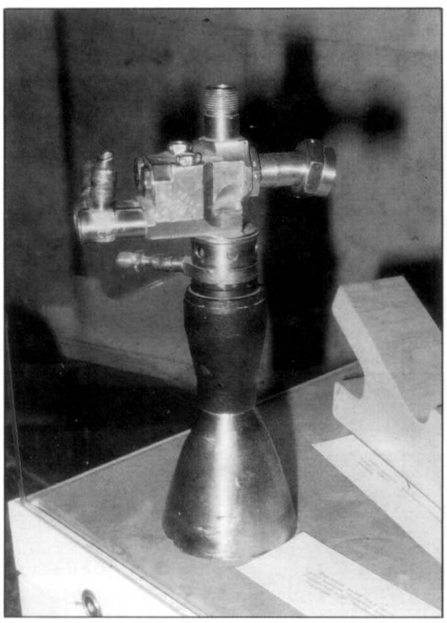
1. N. Kidger, Almaz - A Diamond out of Darkness, ***Spaceflight***, **36**, pp.86-89 (March 1994).
2. J.P. Esders, 'Heavy Kosmos' Revealed, ***Spaceflight***, **34**, p.292 (September 1992).
3. *Aviation Week and Space Technology*, April 2, 1991, pp.20-22.



A manoeuvring engine of TKS generating 400 kg of thrust.

Above: **The orbital manoeuvring engine RD-0225 of the Almaz station.**

Below: **An attitude control thruster of TKS with 40 kg thrust.**

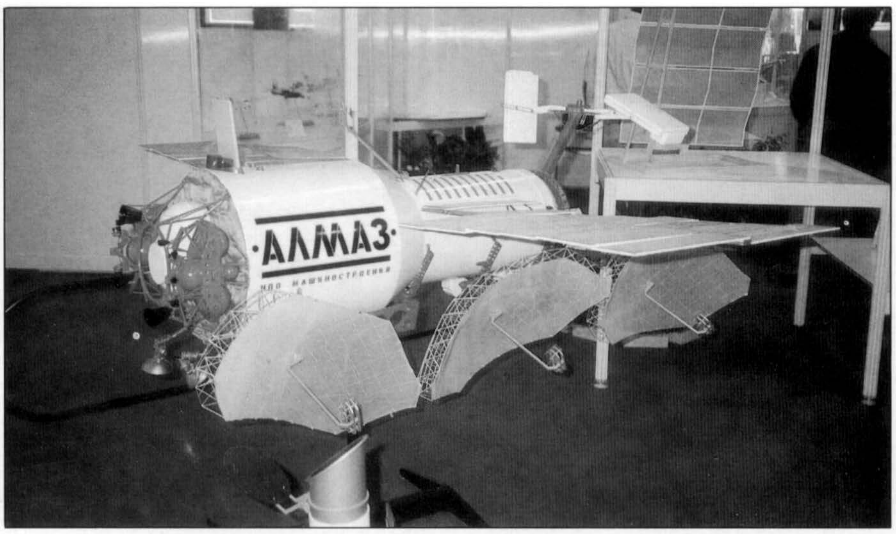


Russia in Space Today

Remote Sensing

The Almaz radar satellite is capable of offering high resolution and all-weather remote sensing operations. It qualifies at the heaviest and most powerful spacecraft in this category.

Th.P./SIC



Other Factors Behind 'Go to the Moon'

I write in response to the article by Lawrence Suld in the July edition of *Spaceflight* regarding the Kennedy decision to 'go to the Moon'. Whilst I would not argue too much against the general thrust of his reasoning, I nevertheless feel that there were other factors at play which came to a head at the meeting on 14 April 1961.

* * *

First, the US Congress had before it proposals from the infant NASA, supported by the House Space Committee, to send "...a manned expedition to the Moon before the end of the decade..." whilst the 1960 election campaign was in full swing. This had come as a result of the work of the Goett Committee. To be fair, the Moon landing was the third of the main recommendations coming after the establishment of a space station!

There is some evidence to suggest that NASA felt sufficiently strongly about this particular objective to pursue it without Congressional approval and was prepared to consider the option of using funds already allocated for the development of a new 'super' booster to do so.

In fact, if one is looking for a birthday for Apollo, then it has to come in this period of planning by the scientists of the space community, Abe Silverstein (Head of the Office of Space Flight Programmes) received a memo from George Low in mid-October 1960 in which he repeated proposals rejected in 1959. The second of these informed Silverstein that Low had formed a group to establish the ground rules for a manned lunar landing. At the bottom Silverstein scrawled "OK". To many this became Apollo's birth certificate. At this moment the Moon landings became a definite goal. All that was needed was a political commitment to ensure the funds.

As far as the space programme in general was concerned the 1960 Presidential elections did not look at all promising. Eisenhower had set out the Republican policy with his dismissal of Sputnik as "...a mere bauble...". There was no evidence to suggest that his nominated successor, Richard Nixon, thought otherwise. Nor did the young Democrat contender promise more. It is widely recognised that the young Kennedy knew little about space nor was concerned about rectifying that deficiency. In fact he intended to disband the National Aeronautics and Space Council after his election.

With this in mind it is no wonder that NASA spirits dropped almost out of sight after the election as Kennedy appointed Jerome Wiesner as his Special Assistant on scientific matters. It was a committee headed by this same Wiesner that issued a report which included the words, "We should stop advertising Mercury as our major objective in space activities. Indeed, we should make an effort to diminish the significance of this programme". (Mercury was the first American manned space programme and success was vital to any further funding for future manned programmes or progress towards reaching the Moon.)

In a perverse sort of way it was this lack of interest by Kennedy and his seeming acceptance of the general thrust of this report that saved Apollo. First, it meant that no scientist was prepared to come forward to take on the job of Administrator of NASA - a political appointment. More by luck than any judgement eventually the choice fell on an extremely capable politician-manager named James E. Webb.

* * *

The second stroke of fortune was that the new Vice-President, Lyndon Baines Johnson, was fascinated by space flight. He actively opposed Kennedy on his plans to disband the NASC and was prepared to use his power as Chairman of the threatened Council to do so. Nor was he a man likely to allow a trifling matter such as the Wiesner Report to stand in his way. So, at a stroke NASA gained the two men most likely to keep its ambitions afloat. Both were widely experienced in deviousness necessary in the political climate prevailing in Washington in those early months of 1961.

* * *

There are other factors to consider before one begins to make value judgements on the meeting of 14 April 1961. Kennedy was the youngest President elected, he was the first Catholic, and he scraped home by the narrowest ever margin. If he was to stand any chance at all of serving a second term he had to ensure the 'southern vote' and he had to make good his promise of boosting a depressed American economy.

His first months in Office brought him up against a Congress not entirely sharing his vision of a 'New Frontier' which meant head-on clashes with unions, racists and foreign governments. However, the young President was determined and astute. Perhaps his greatness lay in his ability to read a situation, capture a mood, and turn both to his advantage. In April 1961 the American people were smarting under the indignity of the Gagarin flight and coming second to the Russians yet again. There was to follow the Bay of Pigs. The voters might not have swallowed increasing Government spending to tackle the Kennedy dream of a freer, more equal society but they would countenance the expenditure of less than one half a percent of the gross national product if it meant restoring American pride. Initially it mattered little to Kennedy whether this involved going to the Moon. It gave him the excuse to spend Federal funds in boosting the economy of the areas where he needed votes, and it gave those same voters a visible example of his desire to restore America as the world leader.

There should be no surprise that the meeting on 14 April lasted for only five minutes. Everything was in place. NASA had the plan ready and in Webb and Johnson they had the political manipulators to see it through. All that remained was the go-ahead from the man that mattered. In April 1961 events outside America made it sensible to seize the moment.

* * *

Perhaps of more interest would be to hypothesize whether America would have gone to the Moon in Kennedy's administration anyway. There are strong arguments to suggest that at some point he would need a grandiose scheme to get support for his political ideals. If this is true, then Apollo should not be compared to Columbus but the Tennessee Valley Scheme of another Democratic President who came to Office facing the same problems as Kennedy. In many respects the two are alike. Both were necessary as high profile projects to concentrate national pride, and both were overtaken by wars which altered national perspectives and cast doubts on the wisdom of concentrating huge amounts of money on such narrow objectives.

* * *

Was the Moon decision political opportunism driven by a sense of self preservation, or was it really made from higher ideals? Are we still too close to the events to make any valid judgement? Whatever history finally decides, it is a pity that Lyndon Johnson, on record as the one real enthusiast in the Kennedy political team, is given so little credit for preserving the structure that made Apollo possible. No wonder he felt somewhat slighted in his later years. E.T. PUGH

Astronauts Meet at Experimental Aircraft Fly-In Convention Oshkosh, Wisconson, 30 July 1994

Right: The Apollo 11 astronauts, Armstrong, Aldrin and Collins discuss their experiences for the 25th anniversary of the first lunar landing. This was the only place in public that all three appeared together. Each gave a riveting first-hand account of the historic flight.

Fifteen Apollo astronauts at the Convention are (left to right): Charles Duke, Al Worden, Stuart Roosa, Dick Gordon, Pete Conrad, Mike Collins, Buzz Aldrin, Neil Armstrong, Eugene Cernan, Jim McDivett, Jim Lovell, Bill Anders, Frank Borman, Walt Cunningham and Wally Schirra.

In the evening a two-hour ceremony was attended by about 5000 people at which each astronaut was honoured for his accomplishments. The time was filled by a wealth of anecdotes and comments by each man. A recurrent comment was that the US lacks the leadership to attempt another programme as ambitious as Apollo. But the real feeling conveyed was that these men, five of whom had walked on the Moon, know that after they have gone there will be no one on Earth who will have walked on the Moon.

Apollo 11 25th Anniversary Celebration at the Kennedy Space Center, 16 July 1994

On the platform is Fred Haise of Apollo 13 (left side); left of the podium is KSC director and shuttle astronaut Bob Crippen; right of the podium is Jack King voice of Apollo launch control and to his right is Rocco Petrone Apollo launch director.

All photos and information on this page are courtesy:
PETER GUALTIERI, WEST KENTUCKY NEWS.

Left: On 15 July, The Center for Space Education was dedicated during a ceremony at KSC attended by families of America's 16 fallen astronauts. The father of Gregory Jarvis (one of the Challenger astronauts) watches during the unique ribbon cutting ceremony.

The Center will feature state of the art educational methods for teachers around the US and the world. Also announced at the ceremony was a new museum to be built in two years time to house the Saturn V (currently lying near the VAB) and other Apollo memorabilia.

Kennedy and the Moon Goal
A Reassessment

At this 25th anniversary of the first human flight to the Moon much has been written about the origins of the decision made by President Kennedy in 1961 to make that objective a US national goal. History has been kind to that era, transforming the White House into Camelot, John F. Kennedy into King Arthur and Jacqueline B. Kennedy into Guinevere. Yet, like that romantic retrospection, it is a myth created in the minds to those who see in Kennedy the epitomy of all their aspirations - about adventure, space and the Moon.

BY DAVID BAKER
Cambridge, UK

The Decision Myth

John Kennedy did not originate the Moon landing concept, he did not set it as a NASA objective and he did not personally decide upon this as a landmark task for the space agency. Kennedy had no grasp of what the space programme was all about and, it can be said with some certainty, had he not attached this single objective to his Presidency with such force, or taken up the campaign with such rhetoric, NASA may have had Moon bases by the 1970s. In private, Kennedy regretted that he could find no equivalent flagpole on Earth from which his standard could fly.

These are strong claims that stand in marked contrast to the popular connection between Kennedy and the Moon commitment but this article will give evidence for all its assertions. It is divided into two sections. The first describes how committed was NASA to a Moon landing objective long before Kennedy became interested in space. The second will show how Kennedy evaded the decision-making process and delegated the final judgements to others, while continuing to have doubts along the way.

The Moon Goal, 1959-60

A manned Moon landing was an entrenched part of NASA planning for two years before President Kennedy gave it backing. It originated in long range plans and projected goals from October 1958 when the agency was formed. Shortly after Mercury had been agreed as the quickest way for America to get a man into space, Harry H. Goett of the Ames Research Center was asked to chair a Research Steering Committee on Manned Space Flight. It had a mandate to examine post-Mercury options and recommend long term goals. The ballistic approach to manned flight was new, its practicality unknown and a departure from the steady progress being made with winged rocket vehicles such as the X-15.

In a programme called Dyna-Soar, the US Air Force was working on a winged re-entry vehicle launched by conventional booster and during the second half of 1958 NASA itself was uncertain whether ballistic or lifting re-entry was the proper way to go after Mercury. It needed to make up its mind because Mercury was a limited programme funded as a proof-of-concept vehicle to throw engineering and human-related systems into space for operability checks. Beyond Mercury, winged or ballistic vehicles were mutually exclusive, for the nation could not afford both.

The Goett Committee met for the first time on 25-26 May 1959, and drew up a tentative list of priorities, including manned space stations, lunar reconnaissance, manned Moon landings and flights to Mars and Venus. The minutes of the meetings show clearly that a manned lunar landing was considered a benchmark for future space activity. From these agreed objectives NASA took the decision to go with the ballistic re-entry concept, since by this date added confidence had been acquired in the development of ablative heat shields for low-cost application. Quite simply, for a long while to come, ballistic re-entry vehicles would be quicker to build and cheaper to operate than winged lifting bodies.

A manned Moon landing was an entrenched part of NASA planning for two years before President Kennedy gave it backing. It originated in long range plans and projected goals from October 1958 when the agency was formed

At the second meeting exactly two months later, John Disher from NASA HQ pointed out that the Army Ballistic Missile Agency was working on heavy-lift launchers in the Saturn program. NASA had recently acquired responsibility of the US Air Force's Rocketdyne F-1 engine (later adopted for Saturn V) and Disher wanted this coupled to an Advanced Saturn (Saturn V) to support a manned Moon landing. Soon, NASA would get the Saturn division of the ABMA. The Moon mission could be flown using a single Nova (a post-Saturn V vehicle with at least 12 million lb thrust) or several Advanced Saturns for initial Earth-orbit assembly.

If there was a single point at which the Apollo programme began it was on 12 August 1959, during the first meeting of the New Projects Panel set up by NASA's Space Task Group under the Chairmanship of H. Kurt Strass. With the objective of a manned Moon landing, precursor steps were outlined involving a new, three-man, spacecraft for two-week missions in Earth orbit. Alan B. Kehlet was charged with setting up the design programme for a spacecraft capable of returning to Earth from the vicinity of the Moon. Six days later the Panel decided that 1970 was a valid target date for the first manned Moon landing.

Meanwhile, primed through leaks and informed meetings behind closed doors, industry had been studying a fast-track to Moon landings. On 1 September 1959, Mercury builders McDonnell Aircraft Company presented a classified report to NASA showing how the one-man capsule could make a circumlunar flight. In one proposed plan to test the spacecraft at lunar-return velocity, a modified Mercury and attached boost stage would be placed in an elliptical orbit by Atlas-Centaur. At an apogee of 1,200 mls, the boost stage would fire and drive Mercury back down to the atmosphere for re-entry at 25,000 mph, lunar return speed.

The pace at which proposals and goals were evolving alarmed some at NASA but Headquarters backed bright young engineers at the field centres. From within the agency came a resolve to push hard for political approval to go for the big one: a manned Moon landing. The mood was epitomised on 2 October 1959 when science and engineering personnel at the Jet Propulsion Laboratory met to consider future missions and decide one issue tabled on the agenda: 'What kind of a space spectacular might the United States perform that the Soviet Union was incapable of doing".

By the end of the year NASA's Space Task Group and the New Projects Panel had charged the Goett Committee with setting an agenda for manned Moon missions. On 8-9 December, at its third meeting, the Committee set stepping-stones involving a 10,000 lb cylindrical laboratory with a 6,000 lb re-entry module for circumlunar missions and a pre-positioned supply base on the Moon's surface for the landing which was to follow.

Over the next six months steps were taken at NASA and in Congress to force action from an apathetic White House. Under the stipulation that US Presidents serve only two terms of four years each, this was the last year Dwight D. Eisenhower could remain in power. Never convinced that a space race was worth the effort, or that important in the long run, Eisenhower took concerted steps to limit the expansion of manned flight plans.

Nevertheless, when NASA's first Long Range Plan was published on 16 December 1959, manned circumlunar flights in the second half of the 1960s, and Moon landings after 1970, were the objectives. In January 1960 a frustrated House of Representatives' Committee on Science and Astronautics was briefed on the plan and on 5 July it declared that "A high priority program shoud be undertaken to place a manned expedition on the Moon in this decade. A firm plan with this goal in mind should be drawn up and submitted to the Congress by NASA".

On 28-29 July 1960, NASA held its first Industry Program Plans Conference in Washington, DC, where prospective bid-

ders heard plans for the new manned spacecraft called Apollo. The name had been chosen by Abe Silverstein in January 1960 to perpetuate the use of mythical gods in the names of manned vehicles. George M. Low, then NASA's Chief of Manned Space Flight, said that Apollo would carry out circumlunar and Earth orbit missions by 1970 and that lunar landings would follow.

NASA moved quickly and on 25 October 1960, awarded three six-month Apollo feasibility contracts, eight days after George Low issued a memo outlining his plans for a Moon landing committee to fix mission requirements. Meanwhile, two Langley Research Center engineers, Clinton E. Brown and Ralph Stone, Jr, devised an efficient Moon mission concept called lunar-orbit-rendezvous. It was presented to NASA HQ on 14 December 1960. In attendance was John C. Houbolt, who had done considerable work on LOR and would eventually persuade HQ to adopt that mode.

The Low Committee received its first briefing on 5 January 1961. The Marshall Space Flight Center outlined a draft plan for Apollo flights: Apollo A in 1965, manned circumlunar return with an Apollo B spacecraft in 1966 and a manned lunar landing and return beginning 4 July 1967. It was suggested by von Braun that the Soviets might celebrate the 50th anniversary of the Russian revolution in October 1967 with a lunar touch down and that the US could achieve a propaganda advantage by celebrating Independence Day with an American Moon landing. The idea stuck, forming the basis for future projections about a landing in 1967. However, in the final report submitted 7 February 1961, the Low Committee recommended Apollo Earth-orbit flights in 1966, manned circumlunar flights in 1967 and landings in the 1968-69 period.

The Low Committee also heard how semi-permanent lunar science stations could be manned with 18-20 people by 1969 with permanent bases from 1971. To support mission objectives, Marshall envisaged 36-48 Saturn V flights a year from 1966 and the use of nuclear powered upper stages. On the very day the Low Committee sat, a two-day meeting began at NASA HQ to decide that a rendezvous and docking vehicle would be an essential precursor to Apollo Moon landings. On 1 February 1961, NASA began talks with McDonnell about a two-man spacecraft, later called Gemini.

Meanwhile, on 10 January, Jerome B. Wiesner from MIT submitted the report of a nine-member ad hoc committee on space to President-elect Kennedy. Although the committee had not met with any key space personnel it blamed NASA for developing an in-house research establishment and giving too much attention to manned flight. Next day, Kennedy made Wiesner his Special Assistant for Science and Technology. When NASA boss James Webb met with Kennedy and Budget Bureau chief David Bell on 22 March to discuss the fiscal year 1962 budget (commencing 1 July 1961), the President refused to increase funds for Apollo. In amendments to Eisenhower's 1962 budget. NASA received an increase of only $126 million versus the $308 million it asked for.

The Kennedy Conversion, 1961

In the second half of 1960, plans to set up the Moon mission moved rapidly. A new President was about to be elected: for the Republicans, Richard Nixon defended the incumbent administration and promised nothing new on space; for the Democrats, John F. Kennedy had plenty to say on the national defence posture - and the space program. That Kennedy was well briefed on both is evident from recently declassified material.

A key plank in the Democrat campaign was fear among some intelligence circles that Soviet war-making plans were advanced and that missile production was expanding. Promising to plug the so-called "missile gap" with a massive escalation in US strategic missile production, Kennedy focused on these fears, exciting public concern with claims that Eisenhower had let fall the defences of the United States at a time when the threat was increasing.

As a nominated Presidential candidate, Kennedy had a right to classified intelligence. On 23 July 1960 he was given the first of three national security briefings by the CIA. A second meeting took place on 19 September and Vice-Presidential candidate Lyndon Johnson was given a briefing on 27 July. At a fourth briefing a US Navy intelligence officer informed Kennedy that projections of a massive missile gap favouring the USSR were not endorsed by the best US intelligence - the one given to the President - and that Eisenhower's missile deployment plans were ample response.

Kennedy also received the opinion that, because it was supposed so much of the Soviet space programme was linked to military capabilities, their spectaculars were likely to run out of steam after a manned flight. Kennedy kept this information confidential and extended his alarmist fears about a runaway missile-gap. When overwhelming evidence in 1961 made it abundantly apparent that there was no missile gap, Kennedy denied he had ever received such briefings, agreeing along with everyone else that it was to be regretted that the information had not been available before the massive US missile deployments began.

The way Kennedy used information is crucial to the assertion that he was a reluctant spacefarer. His campaign was waged on accusations of complacency in the Eisenhower administration. He worked hard to put that message across and pointed to events such as Sputnik and the "missile gap", claiming the incumbent had let slip the presumed supremacy of US technology. By late March 1961, Kennedy was under pressure from all sides to do something and not let Russia grab another space spectacular to embarrass Americans. It was, after all, what he had accused the previous administration of.

Added to this, he was getting a rough ride through Congress which, with a strong Democrat majority, was concerned to see their President honour strong election promises. As if to tease him into action, the New York Times summed up the creeping paralysis of the Kennedy administration when it said "the President's image has been beset by the difficulties he has had with Congress, by his failure to spell out the promised sacrifices . . . and by the continued recession".

Frustrated with Kennedy's limited improvement to NASA's 1962 budget, amended in March 1961, Congress demanded action and Rep. Fulton threatened to seize the initiative when Russia put Yuri Gagarin into space on 12 April 1961. He implored James Webb to "Tell us how much money you need and we will authorize all you need. I am tired of being second . . I want to be first!" Speaking in anger at what he saw as apathy from the Kennedy White House, Rep Anfuso said he wanted "our country mobilized to a wartime basis because we are at war. I want to cut our schedules in half . . . I want to see (a) landing on the Moon".

But still there was no response. Kennedy sought Earth-bound ways to mobilize America and tried to downplay the Soviet space initiative by proposing that "We are, I hope, going to go in other areas where we can be first and which will bring more long-range benefits to mankind". That he was confused over an appropriate response is evidenced by taped conversations with Wiesner. When introduced to the idea of a Moon mission, Kennedy claimed "It's your fault. If you had a scientific spectacular on this Earth that would be more useful - like desalting the ocean - or something that is just as dramatic or convincing as space then we would do it".

When Kennedy learned of the Gagarin flight he was pressed to action, for this was precisely the kind of coup to which the previous administration had given lameduck response. He had to act or face serious erosion of his power base on Capitol Hill. In one sense it was a fortuitous happening: for it would be the gauntlet picked up by his administration that would vindicate his authority and restore confidence in his ailing reputation through foreign and domestic policy.

In this way, Kennedy used the Soviet coup to buy time for his administration and rally support on a wave of national hysteria. That he would always speak positively about space is a matter of record but it was because space had given him the ability to show the Kennedy-style to a wider audience than Congress alone.

Two days after the Gagarin flight of 12 April, Kennedy met with senior advisers and the two top NASA men, Webb and Dryden, in the Cabinet Room. According to the tapes Kennedy was agitated, irritable and impatient, cutting small talk with a direct question: "Now let's look at this. Is there any place we can catch them? What can we do? Can we go around the Moon before them? Can we put a man on the Moon before them? Can we leapfrog?" Dryden launched into strong support for an all-out Moon effort and Webb diplomatically reiterated his faith in Kennedy's ability to choose an appropriate response.

But the President was not convinced

about a major space challenge. "The cost, that's what gets me", he said, turning to David Bell, the Budget Bureau chief. Bell was not too concerned about this and spoke up for putting large sums into high employment programmes at a time when the economy was depressed and Kennedy was being urged to get Americans back to work. Still he was undecided and closed the meeting with the statement: "When we know more, I can decide if it's worth it or not. If somebody can just tell me how to catch up".

Kennedy withdrew to the Oval Office, taking special council Ted Sorensen with him. Sorensen had been briefed several times by Webb when the NASA boss described an evolving sequence of Moon missions leading to established colonies, the NASA plan worked out over the past two years. Dryden advised Sorensen of findings from the Goett and Low Committees, that a Moon landing followed by surface base was both a feasible and a sensible way to unite science and engineering. It would, said Dryden, stimulate US capabilities applicable to technical goods fuelling the export of commercial products.

Unable to fend off the inevitable logic, alone in the Oval Office with Sorensen, Kennedy gave tacit approval for his administration to organise a Moon landing commitment but without the NASA plan for sustained exploration and scientific bases. Kennedy was prepared to concede to a space spectacle rather than some other, Earthbound, challenge, but in making so much of the landing goal he cut off all hopes that NASA had for a progressive and well paced development of bases and scientific research stations.

When Sorensen returned he let slip the comment "We are going to the Moon", more as a statement of inevitability than a conveyed commitment. But Kennedy wanted the record to show that he had explored every alternative and wrote a memo to Lyndon Johnson on 20 April asking for advice on which programme to pursue, even then looking at several options: space station, circumlunar flight, unmanned landing, or manned landing and return. On 29 April Johnson replied that nothing short of a manned landing would stand any chance of beating the Russians.

During April Kennedy had been given evidence from Soviet double-agent Oleg Penkovsky that the SS-6 was not being deployed as an ICBM and that one operational launch site, at Plesetsk, had been prepared for it. Only now were there between one and three SS-6s available for use in anger and there would never be more than four. Tests with the SS-7 ICBM had been halted on 24 October 1960, when a prototype blew up killing missile chief Nedelin and deployment would not begin until 1962. Kennedy was assured that his missile expansion plans were sufficient to achieve the gap he had originally credited to the Soviets. He was now free to allocate funds for other programmes, such as the Moon landing.

Too detailed for space to permit in this article, negotiations and meetings were held all over Washington DC, as the Pentagon, NASA, the State Department and the White House buzzed to Lyndon Johnson's manipulations. Having orchestrated the formation of NASA in 1958 in his capacity as Senate majority leader, Johnson now used his position as Vice President and head of the National Space Council to set the agenda and lay out the programme for House and Senate approval.

Few White House staff members liked the idea and Johnson knew he had to move fast. Kennedy told Johnson he was sending him on a tour of South East Asia on 9 May and Johnson knew he had to clinch the commitment by that date or leave Kennedy to the anti-space lobby already mobilising public works alternatives among Washington lobbyists. On Saturday, 6 May, NASA's Robert Seamans, the Pentagon's John Rubel and the Budget Bureau's Willis Shapley met to write the document that would present the programme for Kennedy's approval.

On through Saturday night they worked

Kennedy focused on the event rather than the intent and stripped NASA of the commitment it had really wanted for three years before Kennedy came to power: a funded mandate to begin the colonisation of the solar system

while Washington feted Alan Shepard for NASA's first manned ballistic space flight, completed the day before. Sunday came and went and James Webb left the Shepard dinner and ball to help with the closing passages, finally signing off on the document in the first hour of Monday, 8 May. Lyndon Johnson was given the document later that morning as he walked to the White House lawns where Kennedy was about to give Shepard NASA's Distinguished Service Medal. Present for the photo-call, Johnson quietly slipped away from a follow-on luncheon and returned to the White House.

Knowing the mood in the White House, Johnson refused to leave the document with aides and insisted on giving it to Kennedy in person as he sat at his desk in the Oval Office. Johnson left for the Far East on Air Force 2 certain in the knowledge that he had effected a coup over the opposition, just as he had when cutting through red tape to set up NASA three years before. He had steered the Defense Department, the Senate and the House to a Moon landing goal using NASA plans as a framework.

Those plans had already gathered momentum. Beginning on 2 May, the Ad Hoc Task group for a Manned Lunar Landing had been set up chaired by William A. Fleming of NASA. It reinforced and extended the conclusions of the Goett and Low committees and provided the baseline for the Johnson document: Apollo Earth orbit flights in 1965, circumlunar missions in 1967, manned landings in 1967-68.

In the nation at large, there was still little support for space programmes. A

Gallup poll taken in the first half of May indicated only 33% believed that Shepard's flight had been worth the money. Kennedy was aware of this and argued with Webb that only the single event of a Moon landing held popular appeal. Of other space projects, Kennedy said that he did not believe there were "many people who feel it's significant to have these kinds of scientific exploits".

When Kennedy drove to Capitol Hill to deliver a 47-minute message to Congress on 25 May 1961, he made some pencil changes to the speech at which he would declare, among other things, the Moon landing goal. Instead of a landing in 1967, he changed it to read "...before this decade is out". Just in case. Just one month later Kennedy offered Khrushchev the opportunity to "go to the Moon together" but it was not taken up after the Soviets pointed out that military secrets would be exposed by cooperation of that sort. Again, on 20 September 1963, Kennedy pressed for a joint Moon landing venture.

From all the evidence there is little doubt that Kennedy found a Moon landing commitment politically expedient and that it was for this reason he picked from NASA's menu of objectives the one event that could unite the nation in a reaffirmation of self-confidence and can-do spirit. In doing so, Kennedy focused on the event rather than the intent and stripped NASA of the commitment it had really wanted for three years before Kennedy came to power: a funded mandate to begin the colonisation of the solar system. We will not truly understand the reasons why that has not yet taken place if we continue to deify the Castle Camelot and heap plaudits upon opportunists.

The real credit for mobilising the Moon mission should go to Harry Goett, George Low, the New Projects Panel and Lyndon Johnson. Without those players, Kennedy would never have had the options from which he approved the single goal selected by his advisors, throwing away in the process so much that could have been done to secure a true foothold in space and a sustained programme of exploration. Had the consolidation of a scientific base on the Moon been the goal selected for a national effort, science, engineering and humanity itself could have gained rewards from which the current generation would benefit. Instead, the new generation must start all over again. Hopefully, this time without another Camelot.

Involved with elements of the US space programme for 30 years, David Baker has just completed a major work on the history of the space programme to be published as a 500,000 word chronology by Facts on File, New York, in 1995.

Apollo Program
*Viewed 25 Years On**

I feel one of the greatest achievements of the Apollo Program was the development of the capability to manage large programmes. Apollo was undoubtedly the largest unified mission ever attempted, but it will not be the last. Someday, the entire world will have to work together on single projects such as those needed to preserve the Earth's environment, or preserve the Earth's resources or undertake a manned mission to the planets or beyond. All will require in one way or another the joint resources, know-how and inspiration of many nations. Apollo experience will be key in all these endeavours.

BY ROBERT F. FREITAG
Director, Field Center Developments at the time of the Apollo Program

Unified and Unclassified Mission

Apollo has one of the simplest specifications ever written. "Land a man on the Moon and return him to Earth, do it safely, all within the decade of the '60s". Later, a goal of $20 billion was agreed upon for the cost. These goals were achieved ahead of schedule and within budget will all mission objectives being fulfilled. Apollo was a single project of $20 billion; it involved 400,000 direct workers in Industry; 36,000 government managers, testers and operators; and thousands of scientists and academicians. It was clearly organised with clean lines of communications. One of the most valuable characteristics of the programme was the openness, with unclassified information and communications, whereby everyone in the programme had easy access to system design decisions and test results.

One very interesting example of these open communications concerned a static firing test of the S-4-B upper stage of Saturn at a test stand in California. The test resulted in an explosion destroying the stage. Within minutes, all contractor and NASA offices were aware of the problem; an on-site investigation quickly sifted through the debris and test data and quickly identified several "suspects" for the cause of the explosion. One item that was particularly suspect was a pressurisation tank which showed a weld failure. Immediately, a panel of the nation's finest welding experts was assembled; the tank manufacturing data were obtained; the design data were reviewed; and tests were run on the failed tank. In a few days it was concluded and proven that an improper welding rod was used to build the tank. Remedies were instituted and almost no delay was incurred. No "cover-up". No delay in "channels". No silence. Just the utmost of cooperation to get the job done.

This concept of openness contrasts so vividly with the intense secrecy in the development of many military programmes and atomic energy. The Congress' and Jim Webb's policy of keeping the programme unclassified, of disseminating information and results to all levels, and keeping the public informed paid great dividends. It was a master stroke of Webb to open Cape Kennedy to the public for them to witness the many NASA launches, to see the facilities and to meet the participants and it proved invaluable to programme support.

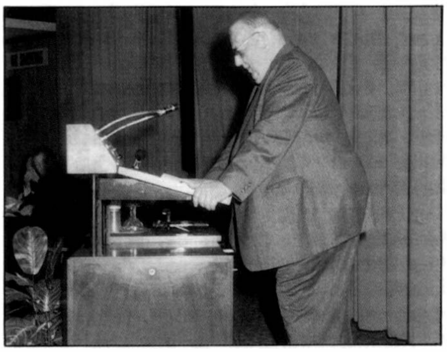
I also recall another aspect of this openness that related to the youth of the nation. I recall talking with children of ages five to ten or so and seeing how knowledgeable they were insofar as the Apollo system was concerned and what it meant to their future. Those same children, for example, when asked about comparable aspects of atomic energy, found the field to be most daunting and mysterious.

Management

The managers and management team for Apollo were especially unique. With a clear national goal as the touchstone, the finest talent in the USA (and elsewhere) was available. Collected under the aegis of the newly dedicated agency, NASA, the management was built from the best of government experts, experienced military managers and operators, top-level industrial talents and renowned experts from the scientific and academic communities. NASA, literally, had the choice of "Who's Who" in American aerospace industry.

The men most responsible for the success of Apollo were from varied backgrounds: Jim Webb (government and industry), George Mueller (industry), von Braun, Debus and Gilruth (government) and Sam Phillips (military). A most important addition to this list has to be Congressman "Tiger" Teague who for the entire duration of Apollo, managed and shepherded the programme through Congress - a very critical role.

One of the little known but extremely effective management schemes was the unusual concept known as the "Apollo Executives". Under this concept, top individuals from the twenty or



Robert F. Freitag delivers his address.
JOZEF G. KNEBA

so Apollo prime contractors met quarterly or were on-call with the top NASA Apollo Program managers. This group was, in effect, the "Apollo Board of Directors". Competition was set aside and united efforts were taken to evaluate programme progress, review and expedite approval of plans, troubleshooting, decision making and other across-the-board elements of programme execution. Needless to say, the cross-fertilisation of ideas, provision of special expertise and the "getting-the-word" firsthand greatly accelerated the meeting of Apollo's goals. I know of no other case where such a unique/government relationship existed.

Why Apollo?

I am sure everyone is familiar with President Kennedy's initiative on Apollo which was basically motivated by competition with the Soviet Union. Clearly, this was the underlying force that insured public support for Apollo; that motivated the Apollo team; and that insured Congressional appropriation of the necessary funds. However, there were other deeper motivations such as the curiosity and urge for exploration and the basic drive and desire to achieve the Apollo goals. And there were yet other factors that were often overlooked. The fact that the ballistic missile race had brought about new, advanced technology in rocketry, inertial guidance systems, space materials, practical transistors and solid-state electronics and advanced computers was a driver that motivated engineers and designers and, coupled with the zest for space exploration and conquering the unknown, spurred on their action.

There was also much political motivation that helped keep the programme sold. For example, Vice-President Lyndon Johnson's grand scheme of developing the "Southern Crescent" on the shoulders of Apollo was typical. This was the establishment of new, high-technology enterprises in the previously rural or underdeveloped sections of the South of the United States. It was Johnson's vision that if key centres for development of Apollo/Saturn were located in the the "crescent" stretching from Houston,

** Based on an address to the joint meeting of the British Interplanetary Society and Cray Electronics held on 13 July to commemorate the 25th anniversary of the first lunar landing.*

Texas, through New Orleans, Louisiana, thence to Southern Mississippi, on to Huntsville, Alabama and ending at Cape Kennedy, Florida that these centres of excellence would prove to be the magnet that would draw tens of thousands of engineers, scientists and managers to the south of the USA and, with one fell swoop, open that part of the country to new growth, development, and technological leadership.

Of course, Johnson was right and in a short decade, the American south became the bell-wether for the nation in becoming the world leader in space flight development and execution. Such institution of modern technology has continued to flower long after Apollo and has permanently raised the standard of living for millions of people.

The derivatives of this great technology stimulus has rewarded the world with uncountable new products, techniques and economic progress such as the computer revolution, equipment reliability, global communications, planetary explorations and has laid the groundwork for the next great operating base in space - the International Space Station with most of the world's space-faring nations involved.

This thought can be extended one more step. Apollo taught America, and much of the world, how to manage and execute large enterprises successfully. This experience will hold all of us in good stead for solving the great problems the world will face in the future. The United States has consistently attempted to inculcate this experience and background into other nations of the world especially Europe, Canada, Japan and, most recently, Russia. Someday, we should all be able to sing from the same sheet of music and the world will be so much better for having enjoyed the fruits of Apollo. ■

Forgotten Names

The Twenty Fifth Anniversary of the Apollo 11 Moon landing has caused, and rightly so, a great deal of reminiscing about the event itself and those who contributed to the success of this historic mission. There are two names which, as far as I am aware, have received no recognition in recent writings about this event and should be added to the list of those making significant contributions.

A great deal has been made about the '1202' alarm during the descent to the Moon's surface. Steve Bales and Jack Garman are the names always mentioned in descriptions of this particular crisis. But who has heard of Gran Paules?

Gran Paules was sitting beside Bales as the second guidance controller for the descent phase. It was he who recognised it as being the same kind of problem that had been rehearsed in the simulators prior to the flight. This realisation that the computer was functioning in a recognisable pattern made the "Go!" given by Bales nineteen seconds after the call a much more logical decision.

The fact that the mission controllers had faced similar problems in training was due to Jay Honeycutt in charge of Simulator Support Operations. Garman let slip that there were such things as 'computer alarms' in a conversation to Honeycutt. These were in the computer as a debugging device and were not expected to appear in a flight. Honeycutt made certain that they did as a training problem.

Why did this alarm happen? A month before launch it was decided to use the rendezvous radar to keep track of the Command Module during the descent. The software was changed and an alteration made to the switch setting in the flight manuals. When it was realised that these changes might cause problems the procedures were cancelled. With insufficient time to remove the software alterations a simple, no risk fix was made. The radar information would be withheld from the computer. This was fine. But the computer did not realise that it was not supposed to have the information and kept trying to read it, a problem compounded by the fact that the switch change for the cancelled procedure was left in the flight manual. Taking up nearly a fifth of its capacity trying to work out an angle that did not exist, it is no wonder it overloaded. The problem was solved for the ascent by simply turning a switch on the rendezvous radar from Auto to Manual.

* * *

The second name omitted from those given credit for seeing Apollo 11 safely through the mission is that of Donald Dionysios Arabian. It was his call just after the landing on the Moon that prevented an unnecessary abort.

Arabian was in charge of the Mission Evaluation Room and it was his responsibility to recommend action to deal with the anomaly that scared everyone rigid, and is not mentioned n most records of the flight. One minute after Eagle had made contact with the surface controllers on the ground noticed an alarming rise in the temperature and pressure readings in a descent stage fuel line. It was believed that this was caused by fuel frozen in the pipe by liquid helium. The problem that exercised everyone's mind was what would happen when fuel heated by the residual warmth from the engine, cooling from its 5000°F operating temperature, met the frozen lump. There was a real possibility that it would explode with the force of a small bomb.

Once an immediate abort had been rejected as impossible because Columbia was out of position, the possibility of clearing the obstruction by briefly firing the engine was discussed. This was ruled out by Arabian. He argued that until they knew more precisely how Eagle was resting on the Moon the sudden movement caused by the thrust of the descent stage engine might cause the LM to fall on its side. While he was convincing the others that this was the only course of action the pressure abruptly fell.

The other problem solved by Arabian and his team was to come up with a solution for arming the ascent stage after Armstrong broke the switch when he backed into it getting ready for the EVA. This was not unimportant as the ascent engine would not fire unless it was armed. Eventually a route using a special sequence of switches and the redundant circuits in the LM was worked out, tested, and passed up to the crew.

Perhaps the above serves to remind us that Apollo was a team effort. Though some names have come to the fore, there are many others who deserve recognition and who made significant contributions to the success of man's first exploration of other worlds.

E.T. PUGH

Kennedy Assassination Factor

In all the comment on the political background to Apollo 11, including Lawrence Suld's excellent article in the July issue of *Spaceflight*, I have seen nothing on an aspect that has long interested me: the effect of Kennedy's assassination.

Most people, if they think about it at all, probably assume that if Kennedy had lived he would have ensured that his commitment was fulfilled. I am not at all certain about that.

The appalling way in which Kennedy's presidency came to an end has exaggerated his popularity. He faced re-election in 1964, and it is by no means certain he would have won. If he had lost the new president might have cancelled the programme. Even if he had won, and survived his second term, Kennedy himself might have slowed or even cancelled it if circumstances made it politic to do so. And, since presidents are restricted to two terms, Kennedy could not in any case have been president beyond January 1969. The programme might have been unstoppable by then, but if it had slowed and the goal of the end of the sixties had been abandoned it might not have been, and the incoming president might then have cancelled.

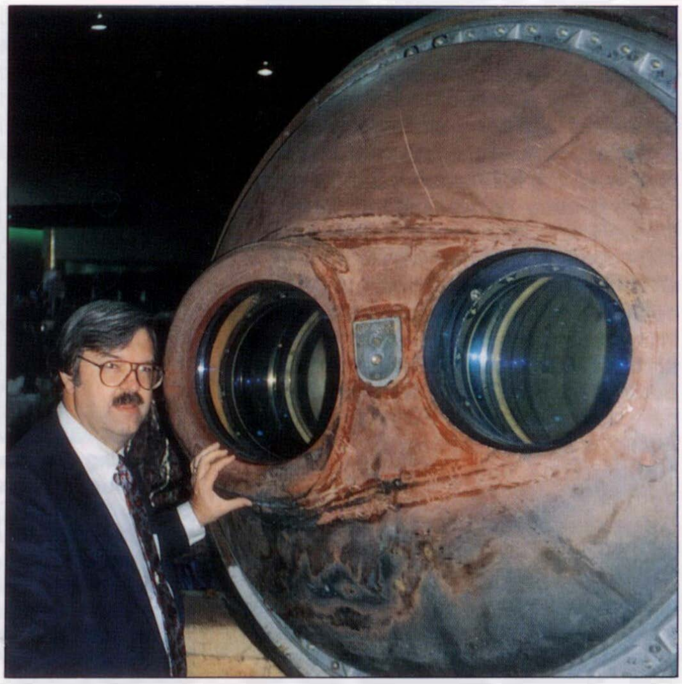
I believe that Kennedy's dreadful death was the impetus to ensure that his commitment should be fulfilled. Whatever happened, it was felt, the programme should go ahead and everything should be done to achieve his goal as a monument to him.

If it had not been for those shots in Dallas I think we very probably would not now be marking the 25th anniversary of the first man on the Moon.

RAY WARD

Correspondence

Interesting Soviet Hardware on Show



James Oberg takes a look at a Soviet satellite designed for military reconnaissance and having two large windows.

Sir, I have the pleasure of sending you for publication some interesting photographs which I took in Houston on 20 July. They show the camera ports of two versions of the Vostok-based observation satellites.

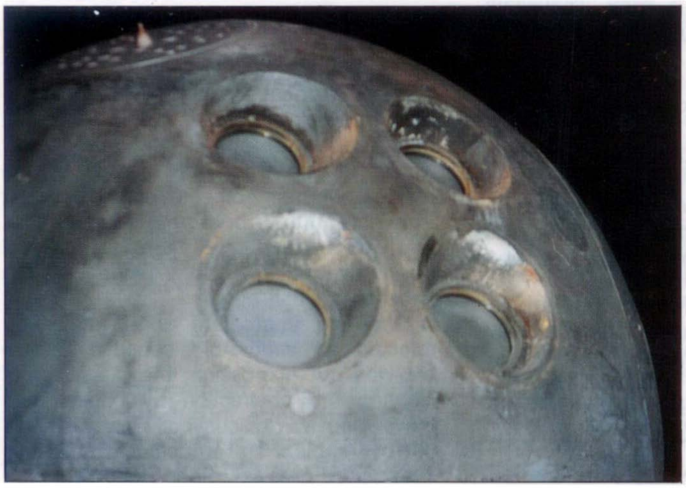
The spacecraft were obtained by Mr Arthur Dula of Space Commerce Corporation, for sale in the Sotheby's auction last December, but they arrived in NY too late. Mr Dula retains full rights to sell them elsewhere. He had them on exhibition at the Houston Astro-Hall during the Apollo 25th celebration banquet.

Mr Dula tells me that both of them flew in 1992, that the four small window version is the Resurs, and that the two large-window version is the military reconnaissance design. Because of the rush to ship them in time for the auction, little preparatory work was done in Russia, and so the "military" vehicle still has all internal equipment, especially the two optics packages, marked Danger - Glass in Russian.

The two windows are off centre because of the internal volume taken up by the parachute compartment. I have not seen the two-window version photographed before, and perhaps readers of ***Spaceflight*** can make useful contributions and commentary on this spacecraft.

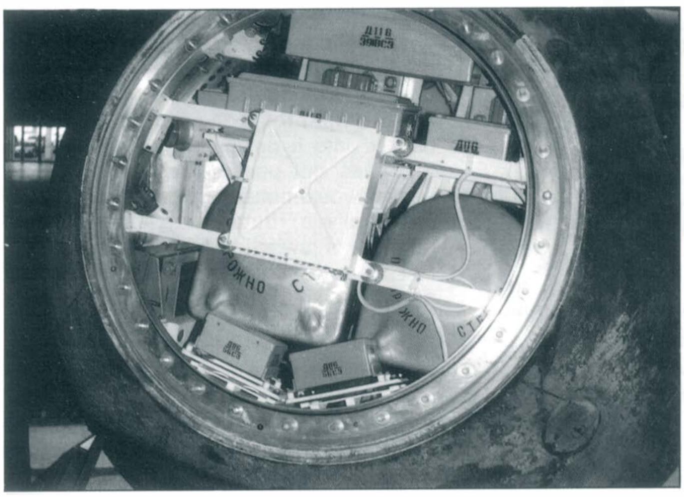
With the help of Geoffrey Perry, I found that a similar spacecraft had been photographed at a Moscow "International Aerospace Salon" by Craig Covault of *Aviation Week*, and the exterior picture (the access hatch was closed so no interior views were possible) was published in his magazine's 27 Sept 1993 issue, p.49. The satellite was identified as Kosmos-2207, which Nicholas Johnson's latest catalog describes as a third generation military photoreconnaissance vehicle. The two vehicles (Moscow's and Houston's) appear identical in random front markings, and indeed, Mr Dula confirmed to me that the spacecraft he obtained is the same one seen in Moscow.

JAMES OBERG
Texas, USA



The Soviet Earth observation Resurs satellite has four small windows.

The removal of a cover plate reveals the internal equipment of the military version.



Apollo Presentations

Sir, On 23 July, a 'Space Day' was held at the Birmingham Museum of Science and Industry - an event organised by the Midlands Spaceflight Society.

The proceedings began with a retrospective on Space Art by the internationally-renowned space artist David A. Hardy, who exhibited a painting of an imaginary Apollo lunar expedition.

David Shayler and Haroon Qureshi at the Birmingham Museum of Science and Industry following the 'Space Day' event.

This was followed by an equally compelling insight into the Apollo project by the noted space flight historian David Shayler (and founder of Astro Info Service), seen standing with me in the accompanying photograph.

HAROON QURESHI
West Midlands, UK

Voskhod-2 EVA Rescue

Sir, I would like to refer to a reference by Mr Dietrich Haeseler in the *Correspondence* section of ***Spaceflight***, July 1994, to a remark by S.P. Korolyov that a Voskhod-2 cosmonaut could be rescued by his fellow crewman. This remark is pure fantasy for a variety of reasons.

For one, the Voskhod capsule could not, as Korolyov implied, be depressurised. The avionics (electronics) in the cabin were of the old style vacuum tube (thermionic valve) which relied on air conduction for cooling. This is why the Russians used such a high internal pressure for their spacecraft, the denser the air, the more efficient the cooling. If the cabin had been opened to space the avionics would have rapidly broiled in their own heat as they could not give off heat in a vacuum.

The Americans had developed the micro-circuit which was more rugged, could withstand greater vibration and did not require an external cooling atmosphere. This is why the Gemini vehicle could be opened to direct vacuum and the Russian vehicles had to use an air lock. This is exactly the reason the Soyuz spacecraft has the configuration it does. In the days when the Soyuz was being designed the Soviets still relied on old fashion vacuum tube technology.

In 1963, Korolyov received copies of a General Electric Company, Apollo Program proposal which outlined that company's configuration for the Command Module. It is believed by some engineers in the US (myself included) that Korolyov used this configuration as his initial design for his future moon ship.

The GE design had a forward air lock, a mid-ship re-entry module (Command Module) and an aft Service Module. Since the Soviets could not depressurise their manned cabin and since they chose to make an EVA between the command module (LOK) and their lunar module (LK) for technical simplicity, they needed an air lock. The GE design was perfect for this need.

Second, the state of Soviet space suit design was very primitive in the middle 1960s, so were American designs. This is why Ed White was so immobile during the first American EVA. The David Clark Company G4C suit was based on a high altitude pressure suit just as the Soviet suit was. The Soviet suit was designed by a very ingenious individual named Stoklitsky of the organisation Ivesta.

Belyayev could not have got himself and Leonov back into the Voskhod air lock as there was only room for one fully suited man. Leonov barely made it in alone. Belyayev could not jettison the fabric airlock without first disconnecting Leonov. It was a catch 22 situation.

Korolyov knew well that the Voskhod could not be depressurised. If he had publicly stated so he would have given away a vital military and strategic secret. As a matter of fact it was not until the defection of Victor Belinko (a MIG pilot) that the US authorities finally convinced themselves that Soviet technology was so primitive. Belinko's MIG had old fashion tubes in the avionics.

I have been writing a book covering the history of American, Russian and European suit development for the past three years. I explain the above topic in detail in the book as it profoundly affected the design of Soviet EVA suits.

GARY L. HARRIS
Florida, USA

Sir, Over the past decade, many articles have shed light on the dramatic flight of Voskhod 2. Dietrich Haeseler's description of the airlock used by Alexei Leonov to exit the descent module (***Spaceflight***, August 1994, p.280) provides new information. Haeseler states correctly that the descent module was not capable of being depressurised, but he also states that mission commander Pavel Belyayev wore an EVA suit in order to be able to rescue Leonov.

Whether or not Belyayev had the luxury of a space suit is still in dispute. Considering the severe weight limitations, it seems unlikely that a duplicate EVA capability could have been provided for Belyayev. In either case, it was not possible for Belyayev to rescue Leonov, as the descent module could not be depressurised. If the airlock outer hatch was opened, as it would have had to have been for Leonov to walk in space, then the entire airlock was exposed to the vacuum of space. To first repressurise the airlock so that Belyayev could enter it from the already pressurised descent module, the outer hatch would have had to have been closed by Leonov, in which case he would not have needed rescue. Further, if Belyayev too could exit the descent module, then there never would have been a need for an airlock in the first place!

DAVID G. FISHER
Williamsport, PA, USA

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

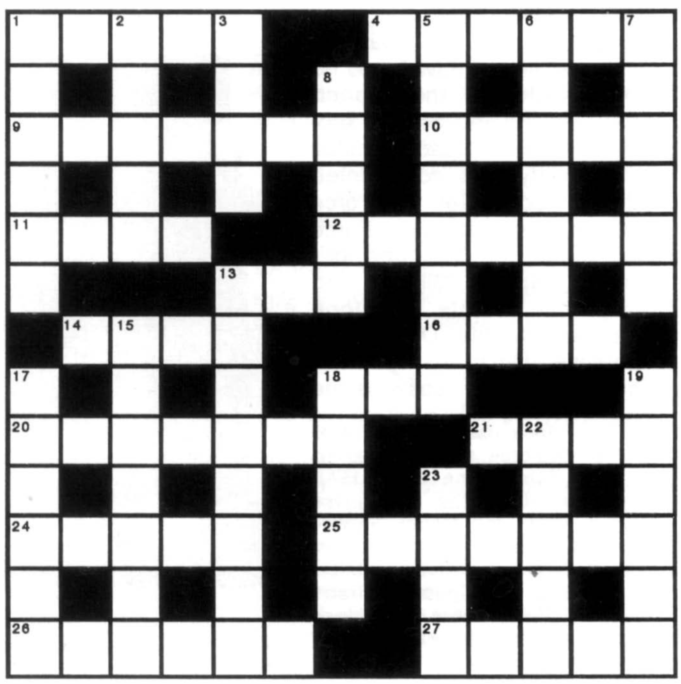
Spaceflight Crossword

No. 14

ACROSS
1+4. Aurora (5,6)
9. Retrieve
10. Approaches
11. Safeguard in electrical circuit
12. Straddling
13. State
14. Small quantity of satellite imagery ?
16. Equips
18. Product of combustion
20. More prepared
21. Space agency
24. Departure
25. Global mobile communications system with a metallic ring ?
26. Stick together
27. Strain to the engineer

DOWN
1. Cleanse
2. Becomes fast
3. Wander about
5. They fire rocket motors
6. Atmospheric re-entry process
7. Solar ———
8. Matrix
13. Horizontal member of framework
15. Make smooth by hammering or rolling
17. Calamitous
18. Rocket propellant casting
19. ——— and sickle
22. Derivative of ammonia
23. Sound of gas escaping

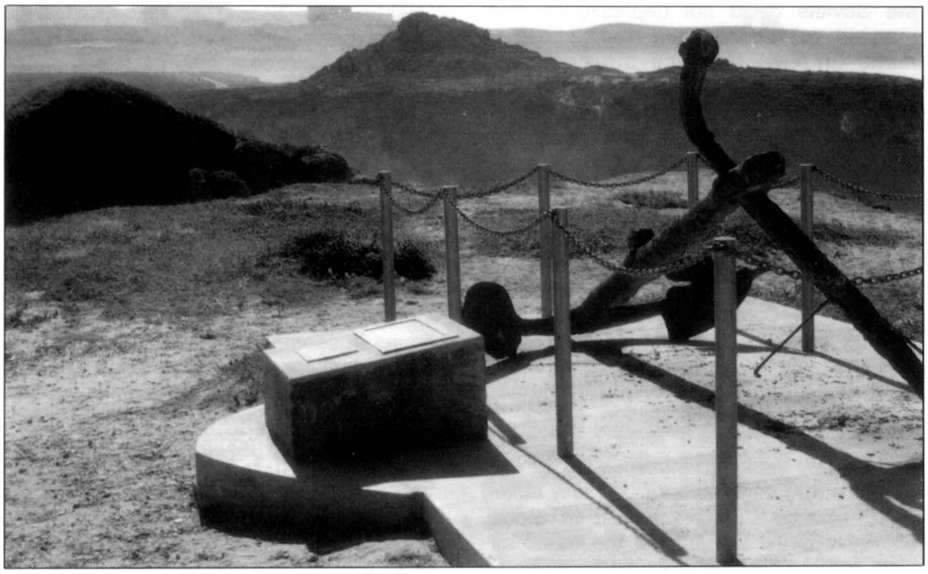
Solution will appear in the November issue.



Solution to Crossword No.13.

ACROSS: 1. Solar; 4. System; 9. Tempest; 10. Upper; 11. Rust; 12. Engines; 13. Bow; 14. SSME; 16. Site; 18. HST; 20. Receive; 21. SPOT; 24. Alien; 25. Velorum; 26. Tenure; 27. Basic.
DOWN: 1. Saturn; 2. Lamps; 3. Reel; 5. Youngest; 6. Topknot; 7. Morass; 8. Strew; 13. Beginner; 15. Suction; 17. Errant; 18. Heavy; 19. Atomic; 22. Paris; 23. Glob.

BY ROGER G. GUILLEMETTE
Rhode Island, USA



A rusted anchor and monument sits on the rocky coastline only several hundred metres below SLC-6. It stands as a memorial to the 23 sailors of US Navy Destroyer Squadron Seven, who were killed on these rocks when their ships ran aground in a fog in 1923. The ships skeletons can still be seen in the churning waters. The buildings of SLC-6 can be seen in the background, also serving as a monument to the dreams of military spaceflight that were twice scuttled on this site and as a reminder of the almost $8,000,000,000 contributed by American taxpayers for a launch facility that has never launched a single spacecraft in its 25+ years of existence. ROGER G. GUILLEMETTE

VANDENBERG

Space Shuttle Launch and Landing Site

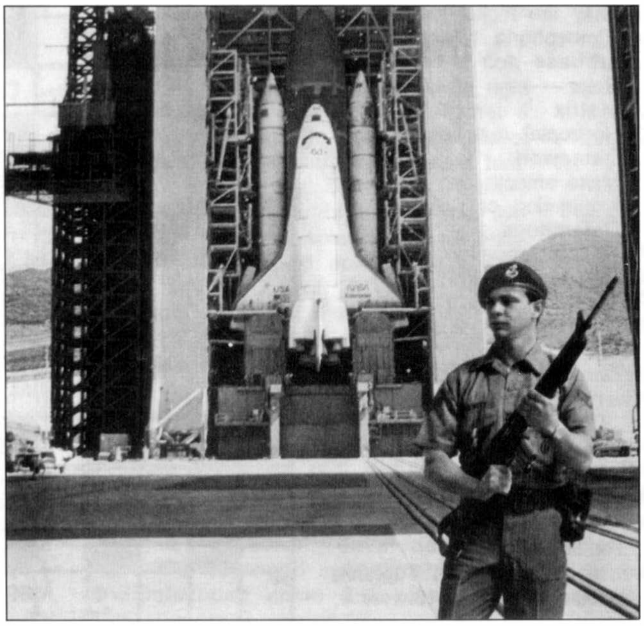
Part 1 - Construction of Shuttle Launch Facilities

Introduction

Since the inception of the program in 1981, all NASA Space Shuttle missions have originated from the John F. Kennedy Space Center in Florida (KSC). The two pads of Launch Complex 39, originally constructed for the Saturn V launch vehicle of the Apollo moon program, were extensively modified and converted for use by the Space Shuttle.

However, the KSC launch pads were never envisioned to accommodate all the launch requirements of the Shuttle program. A second Space Shuttle launch facility was constructed by the United States Air Force (USAF) at Vandenberg Air Force Base, California, intended primarily to support Military and Intelligence Shuttle missions coordinated by the Department of Defense (DoD).

The construction costs alone of this West Coast Shuttle facility, known as Space Launch Complex 6 (SLC-6), exceed $4,000,000,000 (1988 US Dollars). To this date, SLC-6 (nicknamed "Slick Six") has never launched a space vehicle and is, at present, officially deactivated or "mothballed." It still has major technical problems that preclude its use to support construction of the proposed Space Station or for Shuttle missions requiring a polar orbit.



SLC-6 was once used as the backdrop for Air Force recruiting advertisements. This scene of a USAF sentry "guarding" the Enterprise (enclosed within the Mobile Service Tower), along with similar poses, appeared in many popular publications. Today, the public affairs booklet on Vandenberg AFB does not even mention the existence of the launch facility. USAF

The history of SLC-6 is a chronology of hardware failures, uncontrolled schedule slips, lack of operational discipline, inadequate support of supplies, insufficient manpower levels and huge cost overruns. The Air Force underestimated the demands of constructing an extraordinarily complicated facility in a location fraught with major obstacles, both geological and meteorological. Critics contend that the roots of the problems lie in the fact that the military was tasked with the responsibility of constructing a launch complex for a manned space vehicle developed and controlled by NASA.

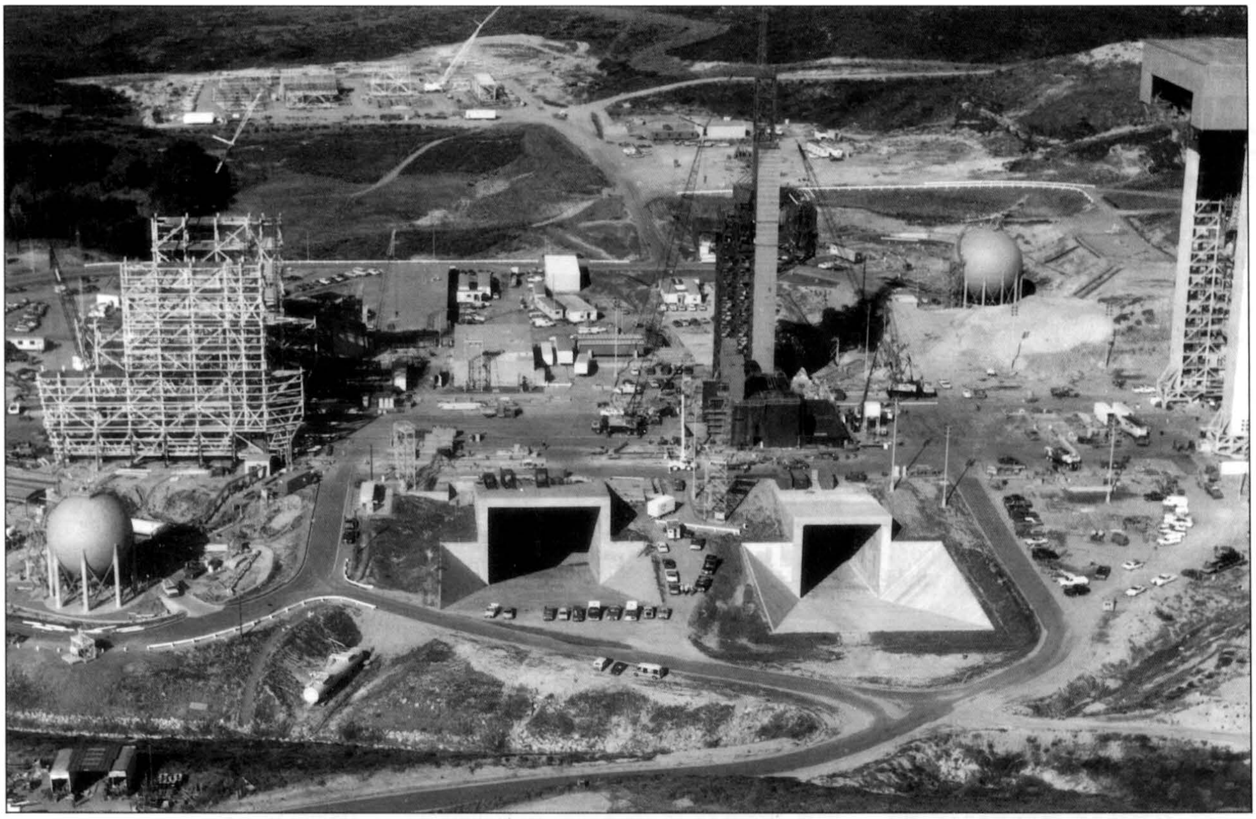
At times, advice or concerns expressed by NASA went unheeded, only to come back to haunt the Air Force in later years resulting in additional costs, schedule delays, and engineering changes made "on the fly." Some will argue that SLC-6 represented "improvisation at its best," that such setbacks were unavoidable with an unproven and challenging design. Others claim that "Slick Six" was a disaster waiting to happen. I prefer to allow readers to draw their own conclusions.

Few details or photographs of SLC-6 have appeared in print in recent years. The latest version of the USAF public affairs publication on Vandenberg AFB does not even acknowledge its existence. The Air Force discourages discussion of the launch complex and is reluctant to provide photographs or technical details. Most of the photographs in this article appear in print for the first time.

Background

Conceived almost thirty years ago, SLC-6 was originally constructed in the mid-1960's as the launch site for the powerful Titan IIIM booster required by the DoD's ill-fated Manned Orbiting Laboratory (MOL) program. MOL was a very ambitious project designed to put Air Force and Navy Astronauts into orbit by 1968. MOL missions were envisioned for periods of up to a month to determine if military officers could perform valuable defence missions in low Earth orbit.

Behind schedule and far over budget, MOL was still three years from operational status when President Nixon cancelled the program in 1969, just weeks prior to Apollo 11. Advances in unmanned reconnaissance satellite technology made many of the original goals obsolete and the spiralling costs of Vietnam siphoned off scarce funds. At the



An aerial view of SLC-6 under construction in early 1984. Note the huge flame trenches for the exhaust from the Space Shuttle Main Engines and Solid Rocket Boosters. The spherical storage tanks for liquid hydrogen (far right) and liquid oxygen (far left) sit on opposite sides of the launch complex. USAF

time of MOL's demise, SLC-6 was only months away from completion. The multi-million dollar complex and all its support facilities, including a 32-storey launch tower, were soon mothballed for the first time.

A decade passed but the dawn of the Space Shuttle era brought with it new opportunities for military space missions and Vandenberg AFB was destined to play an important role. A change in National Security Policy in the 1970's dictated that, once operational, the Space Shuttle would be the sole means of lifting national defence and intelligence payloads into orbit. Expendable launch vehicles, namely the venerable Atlases and Titans of an earlier age, were soon to be replaced by the reusable Shuttle.

The DoD demanded expensive modifications to the original design of NASA's Space Shuttle Orbiter to accommodate very large and heavy DoD and Intelligence payloads that were still on the drawing board. The largest of those classified satellites would require a Shuttle with a huge payload bay and a lifting capacity of over 29,000 kilograms (65,000 pounds) to low Earth orbit, and the capability to reach polar orbit with a 14,500 kilogram (32,000 pound) payload. These changes slowed development and increased the complexity of the Orbiter, but a sceptical US Congress might not approve funding for the Shuttle unless it could also be used by the DoD. NASA had no choice but to alter the design.

In 1975, a special task force designated Vandenberg AFB as the United States' West Coast Space Shuttle launch site, to serve both civilian and military needs. Cost analysis ostensibly demonstrated a savings in excess of $100 million by using the existing MOL site (SLC-6) over building a new complex.

This decision was not without its detractors. A 1978 report to the Congress issued by the US General Accounting Office (GAO), the independent "watchdog" of government expenditures, was sharply critical of the huge expenditures planned for Vandenberg. The GAO concluded, "Single-site STS operations at KSC offer a potential cost saving of $2.3 billion to $3.5 billion. We believe the shuttle's payload delivery capability from KSC is sufficient to handle all defense and civil missions projected for the 1980s" [1].

The GAO's recommendation: "Unless there are compelling national security reasons for the west coast STS site, the Congress should not fund VAFB modifications to accommodate the shuttle". The Congress chose to ignore the study.

Phoenix-like, a new Slick Six was to be reborn from the sandy graveyeard of MOL.

Location

A sprawling complex encompassing almost 60 kilometres of picturesque Central California coastline about 240 kilometres north of Los Angeles, Vandenberg is the West Coast "Cape Canaveral" where the Air Force has launched both military and civilian satellites and tested ICBMs since 1958. Safety constraints and political considerations have prevented north/south launches from Florida's Kennedy Space Center, but Vandenberg is ideally situated on a peninsula with an unobstructed expanse of ocean to the south. Its launch pads are positioned to launch payloads directly over the South Pole into a polar orbit, highly desirable for intelligence gathering missions.

Carved out of a chaparral and oak-covered mountainside overlooking Point Arguelo and Perdnales Point, SLC-6 sits upon ground once considered to be sacred. The ancient Chumash Indians of California believed that it was a holy place where the mist from the sea mixed with the spirits of the heavens. This same mist can reduce visibility of the launch pad to less than fifty metres, and ironically, caused one of the worst peacetime disasters in US Naval history. In 1923, a navigator lost his bearings in a pea-soup fog that shrouded this coastline, causing seven ships of Destroyer Squadron Eleven to run aground on the jagged rocks, killing twenty-three sailors. Several hundred metres below the launch complex, a rusted anchor and plaque stand as a simple memorial to those who perished, the steel skeletons of their ships still visible in the churning waters, seventy years later.

Surrounded by mountains on three sides and bounded by the Pacific Ocean on the fourth, SLC-6 is isolated from operations on the other parts of Vandenberg and completely obstructed from the prying eyes of the outside world, save for brief glimpses from a railroad line that runs along the coast. It is an ideal location for classified national security missions.

Construction of the Vandenberg Shuttle facility began in earnest in 1979, with an Initial Launch Capability (ILC) projected for December 1983. By May 1980, ILC had slipped six months until June 1984. The following month, USAF announced that ILC would slip again until late 1984 due to delays in the start of construction and bids coming in $30 million higher than anticipated. These delays and cost overruns were the first inkling of what was to follow.

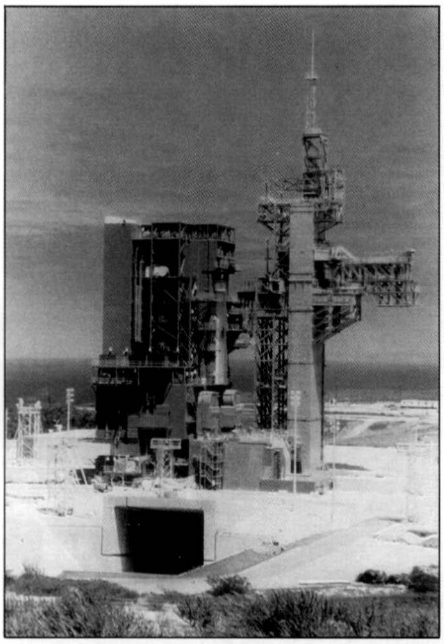
SLC-6 Launch Facilities

Conversion of SLC-6 from a Titan to a Shuttle facility was designed to optimize the existing structures from the abandoned MOL program. The massive 95 metre tall Mobile Service Tower was retained, shortened by about 12 metres and moved back from its original location. "Recycling" this edifice saved an estimated $100 million in new construction costs. The 82 metre tall MOL/Titan IIIM Umbilical Tower was dismantled, but over 700 tonnes of steel were salvaged and later used to construct a smaller Shuttle version.

Existing Titan flame ducts were retained for the plumes from the Space Shuttle Main Engines (SSMEs) and two new concrete ducts were constructed to accommodate the exhaust from the twin Solid Rocket Boosters (SRBs). These ducts contained over 65,000 cubic metres of concrete, enough to construct a standard sidewalk over 560 kilometres in length.

Unlike the Kennedy Space Center where Shuttle facilities are spread out over a large area (the Vehicle Assembly Building is almost five kilometres from the launch pad), most of the major structures that comprise the Vandenberg launch complex are situated in very close proximity to each other and only hundreds of metres from the launch pad and its Fixed Access Tower.

The Launch Control Center (LCC), completed in 1981, was already under construction for MOL when the program was cancelled. It is situated only 347 metres from the launch mount, whereas KSC's LCC is almost 5 kilometres distant from Launch Complex 39. Extensive studies were conducted to ensure that the LCC's half-metre thick walls could withstand launch "overpressures", the code-term for an explosion. Special ventilation systems protected the "inhabitants" from



A closeup of the Shuttle Access Tower, Launch Mount, and the Mobile Changeout Room. The white payload transfer doors can be seen parallel to the launch mount, in the parked position for mating with the payload bay doors of the Orbiter.

JIM BANKE

the toxic byproducts of a launch (or catastrophe).

The stones-throw distance to the pad made the SLC-6 LCC substantially different from KSC's Firing Room, a familiar site to television viewers with its large picture windows looking out toward the distant launch pad. Vandenberg's LCC has no windows, and the firing room consoles (in a strange familiar-yet-different scenario) were arrayed so that operators were seated with their *backs* to the vehicle, the unusual alignment being the source of some gallows humour among launch team members about being lined up for a massive summary execution!

SLC-6 is dominated by three immense movable structures situated on both sides of the launch pad; the Mobile Service Tower (MST), the Shuttle Assembly Building (SAB) and the combined Payload Preparation Facility, consisting of the stationary Payload Preparation Room and the mobile Payload Changeout Room.

The MST and SAB move toward each other on railroad-like tracks and mate around the launch mount. Together, their overhead cranes lift and assemble the Space Shuttle components. Before launch, they roll back to their "parked for launch" positions, only several hundred metres from the pad.

The 7.25 million kilogram, 83 metre tall Mobile Service Tower was extensively modified from its original Titan IIIM configuration. Moving 114 metres from its parked position to the pad (at 12 metres per minute), a 200 tonne capacity crane in the protruding roof of the MST lifts and stacks the Solid Rocket Booster (SRB) segments on the launch mount.

Original plans called for the Shuttle to be stacked on the launch mount without environmental enclosure, despite NASA reservations that the precise tolerances required for stacking could not be met due to wind and weather. USAF had proposed equipping the Payload Changeout Room (PCR) with a strongback crane to lift the External Tank (ET) and place it between the SRBs, then lift the Orbiter and mate it to the ET.

The first Shuttle launches revealed that NASA's concerns over tolerance limits during stacking were well-grounded. The stacking process, conducted inside KSC's Vehicle Assembly Building, was found to require clearances between the ET and SRBs of 0.78 millimetres (31/1000 inch). USAF had only prepared for tolerances of 6.35 millimetres (1/4 inch) while stacking the vehicle outside, exposed to the elements.

"With the wind and the weather at Slick Six, we knew we could never get it down to that" said USAF Major R.L. Peck, quoted in *Time* Magazine. "So, they went back to the drawing boards and came up with the Shuttle Assembly Building. We call it our $40 million one-sixteenth of an inch" [2]. With that, a hastily-conceived and costly "movable weather shelter" was added to the plans for SLC-6.

The 76 metre tall Shuttle Assembly Building (SAB), with its 35 x 18.5 metre American flags emblazoned on the sides, dominates the landscape of the launch complex, almost dwarfing the other massive structures by comparison. The 3000 tonne SAB rolls 87 metres from its parked position to the pad and mates with the Mobile Service Tower, completely enveloping the launch mount. Basically a large empty shell with huge garage-like doors on one side, the SAB's roof inherited the crane originally destined for the Payload Changeout Room. This 125 tonne lift capacity crane, working in tandem with the crane in the MST, lifts the External Tank and places it vertically between the already-stacked SRBs. Then, both cranes lift the Orbiter and mate it to the ET.

The SAB was not the only concession to the weather conditions at Vandenberg. USAF project officials anticipated that problems caused by ice forming on the External Tank would be far more severe than those experienced in Florida during the winter months. To prevent icing, a concrete structure containing two jet engines was constructed to blow warm exhaust through a duct over the ET.

The Payload Preparation Facility provides a clean-room environment to ready payloads for vertical insertion into the Orbiter. Payloads are trans-

ferred from the Payload Preparation Room into the 6000 tonne mobile Payload Changeout Room (PCR) by a special overhead handling system. The 48 metre tall PCR then rolls 229 metres *through* the SAB to the launch mount. Six sliding door panels on the SAB open to permit the PCR to roll into the SAB to mate with the Orbiter and install payloads into its cargo bay.

Other USAF Shuttle Facilities

Space Shuttle facilities were not confined solely to SLC-6; some, the Orbiter Maintenance and Checkout Facility (OMCF) and the Shuttle landing strip with its Orbiter Lifting Facility, were located over 27 kilometres away on North Vandenberg. The Orbiter would be transported from the OMCF to the launch pad, which is surrounded by mountains 240 to 365 metres high by means of a 76 wheel self-levelling Italian-made transporter. Road signs along the route were trimmed to knee-high level or hinged, movable security checkpoints were constructed, and channels were carved into the rocky hillsides to permit the wingtips of the Orbiter to squeeze through 3.2 kilometres of narrow mountain roads.

Built at a cost of $102 million, the OMCF was to have provided a class 100,000 clean-room environment (fewer than 100,000 contaminants larger than 0.5 microns per cubic foot) for the payload bay and crew compartment. The 32,600 square metre OMCF was designed to de-service the Orbiter after flight and remove any payloads returned from orbit, as well as refurbishing the vehicle for the next mission. It also provided the capability to place horizontally installed payloads into the Shuttle.

Special provisions were taken to shield the Orbiter (and its workers) in the event of a catastrophe. The potential for earthquakes in California required the construction of seismic jacks that supported the Orbiter while inside the OMCF. These specially designed supports, capable of withstanding an earthquake of 7.0 on the Richter scale, were built directly into the ground and did not touch the building, seismically isolating the Orbiter. A deservicing pit for payloads returned from orbit, located 15 metres underground, was designed to protect the OMCF from a pyrotechnic/propellant explosion.

The OMCF was never completed. Originally scheduled to be operational at the time of Initial Launch Capability, full operational capability was deferred until February 1987, slipping again into 1988 at the time of the Challenger disaster. USAF had decided that the small number of planned Vandenberg launches in the first few years would permit them to stretch out construction of the OMCF, both to stretch out costs and divert scarce manpower resources to finishing work on SLC-6.

The Orbiter Lifting Facility was designed to lift the Orbiter off the Boeing 747 Shuttle Carrier Aircraft after they landed on the airstrip. This mate/demate device was designed so that it could be partially disassembled and shipped by air to contingency landing sites for both KSC and Vandenberg launches. New Vandenberg abort sites were also established; Easter Island, off the coast of Chile; Hao Island, an Atoll in the South Pacific used by France to support atomic testing; and Eielson AFB in Alaska.

Orbiters for the first three Vandenberg Shuttle missions were to have been serviced at KSC, then, the flight-ready spacecraft would been flown back to California on the Boeing 747 ferry craft and prepared for the next launch. Beginning with the fourth West Coast mission (originally planned for 1987), Orbiters were scheduled to glide back to Earth and land on Vandenberg's strengthened and extended 4.57 kilometre long runway, providing conditions similar to KSC and Edwards AFB landings.

An old Coast Guard lifeboat station on South Vandenberg was reconstructed into a docking facility, complete with a man-made harbour, to accommodate the sea-going barges that transported the 47 metre long External Tanks to California. Arriving ETs were towed by a tractor 3.7 kilometres to the ET Checkout and Storage Facility, capable of housing up to five tanks. This extra storage capacity was considered crucial, enabling ETs to be stockpiled in times of crisis when barge passage through the Panama Canal could not be assured.

A very unusual view of *Enterprise* stacked on the launch mount, looking through the open doors of the Shuttle Assembly Building. The Payload Preparation Facility, with its mobile Payload Changeout Room attached, is in the foreground.
FROM THE COLLECTION OF HARRY BERNARD

The narrow roadway cut through the mountains that connects SLC-6 to North Vandenberg. The Orbiter was to be towed 3.2 kilometres over this road from the preparation facility to the launch pad. Note the grooves carved into the rock of the mountainside to allow the tips of the Orbiter's wings to pass. Also note the tiny roadsign in the foreground; all roadsigns were cut down or hinged to pass under the Orbiter's wings. JIM BANKE

The Air Force also owned their own recovery ship, the MV Independence, to recover the pair of SRBs from the ocean after a launch. The spent boosters would be towed to Port Hueneme, about 160 kilometres to the south. The SRB Retrieval and Disassembly Facility was constructed there to break down the boosters into segments to be trucked back to South Vandenberg.

Near SLC-6, the SRB Refurbishment and Subassembly Facility was built to process the used segments, removing the toxic residue from the propellants as well as washing off the corrosive sea salt. Unused Solid Rocket Booster segments were also to be prepared for launch at this facility and then moved to the launch pad on a special SRB transporter, designed to keep segments level and vertical while travelling over grades of up to 6%.

In February 1985, an all-military crew was announced for the first manned polar-orbit space flight of the first Shuttle mission to be launched from SLC-6.

*(Subsequent events are described in Part 2 of this article which is due to appear in a forthcoming issue of **Spaceflight**).*

Space Satellite Handbook

A.R. Curtis, Gulf Publishing Company, Distributed by Plymbridge Distributors Ltd., Plymouth, PL6 7PZ, 1994, 346pp, £29,99, ISBN 0-88415-192-1.

The third edition of this encyclopedia lists all the satellites and other objects which reached orbit, so encompassing more than 22,000 satellites, payloads, platforms, rockets and debris from all countries, including thousands of man-made objects that have remained in orbit dating from as far back as 1958, besides listing thousands more which have since decayed and no longer circle the Earth.

The latest data from NASA and other Agencies have been used. The listing sets out the official international number of each satellite, its popular name, launch date and country of origin. Orbital parameters included are revolution, inclination, apogee and perigee. A scoreboard compares satellites from various nations and international space organisations.

As before, the book provides text and data about satellites under various classifications, ending with a Glossary and list, up to June 1993, of all the objects launched into Earth orbit.

Understanding GMDSS, The Global Maritime Distress & Safety System

Laurie Tetley and David Calcutt, Edward Arnold (Distributors: Bookpoint Ltd, 39 Milton Park, Abingdon, Oxon OX4 4TD), 311pp, 1994, £29.95, ISBN 0-340-61402-5.

Massive changes have taken place in distress alerting, with communications nowadays carried out on a global scale. The embryo of a new system, (GMDSS) began operation in February 1992 and is to be developed further over a transitional period up to February 1999, by which date it will become fully operational. Not since 1912, which saw the tragic loss of the Titanic, has there been such a radical change in maritime communications.

The new system is already extending the frontiers of mobile radio communications by building a complex highly-reliable radio net which encompasses the world, and which takes global mobile communications forward into a new era. Both terrestrial and satellite communication methods are being interlocked to produce a scheme which allows relatively inexperienced operators to use any equipment to alert rescue authorities.

The maritime radio officers who communicated by morse code have long gone and replaced by the on-board operator whose secondary task is to operate radio communications equipment. Skills-training is now of so short a duration that radio communications terminals can be operated by virtually anyone.

The aim of this book is to provide these new radio operators with all that is needed to understand the GMDSS and its related systems. It falls into three major sections. The first describes GMDSS itself while section two shows how satellites in general, and the Inmarsat system in particular, nowadays provide relatively easy distress procedures. Section three describes terrestrial radio communications and culminates with a description of some of the modem radio equipment available, ending with a detailed glossary and abbreviations section.

Meteorite Craters and Impact Structures of the Earth

P. Hodge, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 124pp, £25, (US$49.95), ISBN 0-521-36092-7.

Countless asteroids and meteorites have impacted the Earth during its five-billion year history. Scars can be found on every continent.

This book describes 139 such sites, spread world-wide, where evidence of impacts may still be seen. They range from recent craters formed this century to those now highly-eroded and a billion-years old.

Some impact sites are spectacular to visit. Examples are the Meteor Crater in Arizona, the Ring-Shaped Mountains of Gosses Bluff, Australia and the huge crater at Ries in Germany. The book presents a summary table for each site giving location, size, age and present condition. Descriptions include guidance about access and suggested itineraries when visiting some of the larger structures.

Space Almanac

A.R. Curtis, Gulf Publishing Company, Distributed by Plymbridge Distributors Ltd., Plymouth, PL6 7PZ, 1994, 746pp, Paperback £21.99, Hardback £30.99, ISBN 0-88415-039-9.

This handy database-in-a-book covers just about everything one may wish to know about space exploration. It features Space Shuttles, Stations, Rockets and Satellites, Astronauts and Cosmonauts, the Solar System and Objects found in Deep Space.

It also includes comprehensive listings of the space activities of America and the former USSR, besides those of Germany, Japan, China, India, Israel, Brazil and the European Space Agency.

A number of very useful appendices conclude the book.

COMPUTER SOFTWARE

Minor Planet Databases

CERES (Version 2.1), a database of Minor Planets published by the Institute of Theoretical Astronomy, St Petersburg, Russia and distributed by White Knights Trading Co., 520 NE 83rd St., Seattle, WA 98115, USA. Tel 0101-206-525-8399. Available for IBM PCs and compatibles on 3.5" and 5.25" diskettes. System Requirements: EGA/VGA display, 640 Kbytes RAM, 6.5 Mbytes hard disc space. Math coprocessor highly recommended, printer optional. US$150.00.

STAMP-94, a database of Minor Planets, O.M. Kochetova and V.A. Shor, published by Institute of Theoretical Astronomy, St Petersburg, Russia. Also distributed by White Knights Trading Co. Available for IBM PCs and compatibles on 3.5" and 5.25" diskettes. System requirements: EGA/VGA display, 640 Kbytes RAM, 2.9 Mbytes of hard disc space. Price US$75.

CERES is a DOS-based integrated software package for Minor Planet research which incorporates a database of over 5000 numbered minor planets compiled from observations made at over 450 major observatories, together with a range of software tools for querying the database and presenting the results. CERES can generate ephemerides for any Minor Planet in the database relative to a range of coordinate systems. The results can be sent to the screen, to a disc file or to an attached printer if one is available.

To assist location of minor planets, CERES includes a star catalogue of approximately 200,000 objects, from which it can generate star charts on screen or as hard copy, showing the paths of selected Minor Planets against the stars as seen from any location on Earth. CERES also includes a facility to show up to seven simultaneous Minor Planet orbits to variable scale and orientation. The relative motions of each Minor Planet can be animated. An on-line help facility is provided and there is also a User's Guide in English (not reviewed).

For this review, CERES was tested on a 486 DX PC running at 33 MHz under MSDOS 5.1. Installation was slightly complicated because the diskette labels did not match the requests from the installation program but, once installed, CERES proved to be fairly easy to operate and it performed searches and calculations rapidly on the example Minor Planets chosen for this review which were Vesta, Geographos and Lencarter. The translation from the Russian is not perfect but was adequate for this reviewer.

STAMP-94 is a DOS-based computer version of the Yearbook "Ephemerides of Minor Planets", also published annually by the Institute of Theoretical Astronomy at St Petersburg, Russia. STAMP-94 is endorsed by committee 20 of the IAU. In addition to reproducing the tables of the Year-book, the package is claimed to assist with typical problems associated with the practical use of the tables. STAMP-94 allows selecting and sorting of data, drawing histograms, interpolating ephemeris data, ascribing the observed positions of objects to the numbered minor planets (identification) and visualising the mutual positions of minor planets at certain moments. A simple menu interface is provided which proved fairly easy to navigate. Data for 1992, 1993, 1994 objects is available separately on request. STAMP-94 occupies less disc space than CERES and may be less complete. For example, the review copy of STAMP-94 was able to locate data on Vesta and Geographos by name but was unsuccessful in the case of Lencarter. A subsequent search using the corresponding Minor Planet number 3817 retrieved some data, except the name.

Both CERES and STAMP-94 are utility programs aimed at the practising observer of Minor Planets who is at ease with the technical parameters involved with such observations. Those with a more casual interest in Minor Planets should first consider a less specialist product such as "Dance of the Planets", reviewed in ***Spaceflight*** in 1993.

These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.
Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

Membership Renewal for 1995

Renewal Forms are currently being dispatched to members who are asked to give them their prompt attention. Members will be pleased to note that subscription rates for 1995 are unchanged from those of 1994.

The early return of Renewal Forms greatly assists the Society with arrangements for its 1995 programme, particularly in respect of its publications, and eases the extra administrative work that arises towards the end of the year at Society HQ. Your help in this matter would be greatly appreciated.

***Binders for* Spaceflight *and* JBIS**

The Society offers special binders for annual volumes of ***Spaceflight*** and ***JBIS***. These may be ordered directly from the Society at any time or on the Renewal Form. Prices (incl. p&p) remain unchanged.

The binders conveniently hold 12 issues of either publication and are a useful way of keeping back numbers handy for future reference. Binders for 1995 issues may be ordered now.

A number of other Society items are available and may also be ordered on the Renewal Form. All prices (incl. p&p) remain unchanged and proceeds from the sale of these items support the Society's Development Fund.

Society's Development Fund

Dr Paul Thompson, BIS President writes:

"There is much that awaits the Society to do to augment its future work, but what can be done and how soon depends largely on the financial resources at its disposal. This is why our Development Appeal Fund is so important.

Regular income goes to provide ongoing member services. But the Development Fund enables the Society to take on a larger and more effective role in promoting space both in the interests of members and the wider community."

The Society welcomes donations to this Fund at any time and appeals to members to give careful consideration to the matter when returning their Renewal Forms. In recent years, the Fund has realised £4-5000 annually from individual contributions and from various fund-raising activities. There is now an urgent need for the Society to be able to meet increasing demands on its resources, particularly in the wide-ranging area of Space Education, and it is therefore appealing for contributions to support this work.

Soviet Astronautics

Technical Symposium of the Society, 4 June 1994

On the 4 June 1994 the Society held its annual symposium on the Soviet Space Programme. Thirty-five Members, Fellows and guests drawn from six countries heard a number of presentations on the space programme of the old Soviet Union and the new Russian Federation.

This symposium has been running for over 10 years and has become one of the most respected Forums for discussing Soviet programmes. Among this year's presentations was a review of current cooperation between Russia and NASA given by Dave Shayler and a review of the organisation of the command and training structure at the Yuri Gagarin Cosmonaut Training Centre. The theme of current developments was continued by Brian Harvey who looked at the new projected launch centre at Svobodny 18 in the Russian Far East.

The symposium also heard some historical papers on the Soviet space programme. Phil Mills looked at Military Salyut (Almaz) Recovery capsules, Brian Harvey reviewed early rendezvous and docking failures in the Soyuz programme and another speaker looked at the Soviet High Altitude Manned Balloon Programme 1930-1960s.

Nigel Evans and Bart Hendrickx gave a firsthand account of their visits to the Baikonur Cosmodrome. Also other participants gave a number of insights into the current state of Russian Cosmonautics. Anders Hanssen gave a talk on the current thinking on the problems with exercise on long duration missions.

The issue of space debris incidents involving Soviet and Russian launches was the theme covered by Phil Clark who has spoken regularly at every previous Soviet symposium. Also shown were films on launch failures and the role of women cosmonauts within the Soviet Manned Programme.

This symposium was a tremendous success with a packed but informative programme. All those who attended really enjoyed it. Another symposium is planned for 1995.

The chairman of the symposium was Rex Hall.

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JBIS 'Space Education' Issue

The current October issue of ***JBIS*** further exemplifies the Society's ongoing involvement in Space Education. This double-size issue is devoted to Space Education projects and support in higher education. Details are overleaf.

'Thank you' Letters to the Society

Project Success

I would like to thank you for helping me get a silver crest award for my project on astronomy.

GHAZALA ROZENA
Birmingham, UK

School Summer Fair

The School would like to thank you very much indeed for your generosity. Your gift was put to good use and helped us to achieve a grand total of £3,000.

We are well aware that requests of this nature are being made to you with increasing regularity from other schools and organisations, and would just like to say how much we appreciate your kindness and support.

DIANE PARRY, Chairperson - PTA
St Paul's C of E Primary School
Chipperfield, Herts

Education Project Advice

Thank you very much for your letter and the copies of ***Spaceflight*** that you sent me. The advice was very much appreciated and very helpful in deciding what we will be doing for our education project.

We are developing material which we will be testing during weekend workshops to which we will invite teachers-in-service. Once we are sure that the material is suitable for use in schools we will use your idea, and publish it in a magazine called *Archimedes*. This is a monthly science education magazine to which most of our schools subscribe.

Once again, thank you very much for the advice that you gave.

JEANINE SLETTEVOLD
Education Liaison Officer
South African Astronomical Observatory

'Space Launchers' Competition Winners

Winners to whom book prizes will shortly be dispatched are:

First Prize:

M. Perman — UK

Runner-Up Prize:

K. Seidensticker — Germany

Consolation Prizes:

S. Coleby — UK
S. Moore — UK
K. Pavitt — UK

The correct answers are: 1. Atlas II; 2. Ariane 5; 3. Delta II; 4. Soyuz; 5. Long March; 6. Ariane 4; 7. Proton; 8 Titan IV.

SATELLITE DIGEST-269

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Soyuz-TM 19	1994-036A	Jul 1.52	Tyuratam	Soyuz	7,150 ?	Jul 3.70	51.65	92.52	396	400	[1]
FSW-2 2	1994-037A	Jul 3.33	SCT	CZ-2D	2,600 ?	Jul 3.56	62.95	89.67	174	343	[2]
Cosmos 2282	1994-038A	Jul 7.00	Tyuratam	Proton-4	3,000 ?	Jul 22.93	2.29	1,435.96	35,755	35,813	[3]
Columbia	1994-039A	Jul 8.61	KSC	Shuttle	103,710	Jul 8.75	28.45	90.55	300	304	[4]
PANAMSAT 2	1994-040A	Jul 8.96	Kourou	Ariane 44L	2,920	Jul 14.87	0.05	1,436.39	35,648	35,937	[5]
BS 3N	1994-040B				1,210	Jul 30.86	0.19	1,436.20	35,777	35,800	[6]
Nadezhda 4	1994-041A	Jul 14.22	Plesetsk	Cosmos	825 ?	Jul 16.90	82.95	104.68	954	1,005	[7]
Cosmos 2883	1994-042A	Jul 20.73	Plesetsk	Soyuz	6,500 ?	Jul 20.85	67.11	89.50	169	330	[8]
APSTAR 1	1994-043A	Jul 21.44	Xi	Chang CZ-3	1,383	Jul 28.19	0.05	1,436.00	35,651	35,919	[9]
Cosmos 2284	1994-044A	Jul 29.40	Tyuratam	Soyuz	6,500 ?	Jul 30.20	70.38	89.41	214	277	[10]

NOTES

1. Two manned spacecraft, carrying Y.I. Malenchenko (commander) and T.A. Musabayev (flight engineer) to the Mir Complex: Musabayev is a Kazakh cosmonaut. Docked with the Mir Complex 1994 July 3.58.
2. Second flight of second generation Fanhui Shi Weixing ("Recoverable Test Satellite") satellite, launched from Shuang cheng Tzu (Jiuquan) for remote sensing and microgravity experiments. The re-entry module was recovered 1994 July 18.15.
3. Second generation early warning satellite in the Prognoz series, stationed over 335 °E.
4. Carried seven astronauts on IML-2 mission (International Microgravity Lab): R.D. Cabana (commander), J.D. Halsell (pilot), R.J. Hieb (payload commander, mission specialist, MS-1), C.E. Walz (MS-2), L. Chiao (MS-3), D.A. Thomas (MS-4) and C. Naito-Mukai (payload specialist, first Japanese woman in space).Mass quoted above is that projected for landing which took place at KSC July 23.36.
5. PANAMSAT 2 is a communications and video satellite, operated by PanAmSat in Greenwich, Connecticut (USA). Initially located over 195 °E, but to be operated over 191 °E.
6. BS 3N is a direct broadcasting satellite, operated by MM Astro Space for Nippon Hoso Kyokai and Japan Broadcasting Inc, Tokyo. Satellite initially located over 121 °E, but its planned operational location is 110 °E.
7. Civilian navigation satellite, incorporating COSPAS-SARSAT search and rescue transponders.
8. Yantar fourth generation, close look photoreconnaissance satellite, expected to remain in orbit for about two months.
9. APSTAR 1 launched by China for the APT Satellite Company Ltd of Hong Kong for communications. Initially located over 137 °E, but to be operated over 131 °E.
10. Cometa fourth generation topographic and mapping photoreconnaissance satellite, expected to remain in orbit for 40-45 days.

ADDITIONS AND UPDATES

1994-001A Soyuz-TM 18 with cosmonauts Afanasyev and Usachyov undocked from the Mir Complex 1994 July 9 and landed 1994 July 9.44 (10.13 GMT).

1994-027A SROSS C2 performed a series of manoeuvres to lower its orbit during early July 1994: add the following orbital data (the first orbit is pre-manoeuvre and the final one is after the manoeuvres were complete):-
July 2.09, 46.04°, 98.27 minutes, 433 km, 919 km
July 7.14, 46.04°, 95.19 minutes, 432 km, 623 km

1994-031A Progress-M 23 released a Raduga recoverable capsule which was recovered 1994 July 2.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight/JBIS*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

6 October 1994 — 7 - 8.30 pm

The First Manned Lunar Landing Spacecraft: Its Design, Manufacture, Ground Test and Mission

Ross Fleisig,
Therus Dynamics Inc., New York

The Apollo 11 space vehicle is described with emphasis on Lunar Module 5 (LM-5). Finally the mission itself with LM trajectories is reviewed.

2 November 1994 — 7 - 8.30 pm

Chinese Space Programme

Phillip Clark,
Molniya Space Consultancy

A review of the programme's history, a look at its current status and an attempt to predict in which directions we can reasonably expect the programme to continue.

7 December 1994 — 7 - 8.30 pm

Collision of Comet Shoemaker-Levy 9 with Jupiter

Prof. I.P. Williams,
Queen Mary and Westfield College, University of London

The impact of Comet Shoemaker-Levy 9 with Jupiter provided the world with a spectacular event, images of which were reproduced widely on Television and the Press. However the event was more than a spectacle. New information was obtained on the dynamics of orbits, the structure of SL9, the composition of SL9, the atmosphere of Jupiter and the structure of the planet. The talk will show many of the images and give an overview of the new results.

1 February 1995 — 7 - 8.30 pm

Great Balls of Ice - The Satellites of the Outer Planets

Dr David A. Rothery,
The Open University

The giant planets have considerable families of satellites, all icy except Io. Counting Pluto and Charon, there are 18 icy bodies large enough to have assumed spherical shapes (>200 km radius). Although their outer regions are icy, the processes that occur upon and within them mimic the geological processes, such as volcanism and tectonics, with which we are familiar on terrestrial planets.

5 April 1995 — 7 - 8.30 pm

Alternative Space Launch Concepts

Colin Jack,
Oxford Mathematical Designs

Launching orbital payloads by rocket costs upwards of £4,000/kg. Many potentially cheaper ways have been suggested, ranging from the plausible to the fantastic. But how to tell which is which? Can we rely on the judgement of the big space agencies? Colin Jack will be discussing the proposals, and trying to pick some winners. Suggestions from the floor will be welcome!

The 49th Annual General Meeting of The British Interplanetary Society held on 13 August 1994

Result of Poll* on the Resolution:

To receive the Report of the Auditors and the audited accounts for the year ended 31 December 1993.

For: 246 Against: 14

Scrutineers:

A.P. Black, FBIS; E. Waine, FBIS

The Resolution to reappoint the present auditors was defeated** and four other Resolutions were passed***.

* The Poll included Fellows present and voting and those absent who had submitted Proxy Forms expressing their voting wishes.

** Auditors will be appointed in compliance with Section 387 of the Companies Act.

*** A copy of the revised Memorandum and Articles is available on request from the Executive Secretary.

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

66 SUSSEX

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Spaceflight

The International Magazine of Space and Astronautics

Space - at Farnborough 1994

UK Minister Opens Pavilion

Shuttle News

Activities on Mir

Air Launch to Orbit

Solar Sails and Kites

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SPACE '93 Satellite Link-Up

A fascinating, informative chat by Arthur C. Clarke, describing his work - past, present and future, as he responds to questions put by BIS members at the Society's 60th Anniversary Meeting on 17 October 1993.

The question and answer session is led by astronomer and "Sky at Night" TV personality Patrick Moore and by lunar astronaut Buzz Aldrin. A lasting and entertaining record of a unique occasion.

The video pictures are exclusively of Arthur C. Clarke, with audio presentations by other participants. *50 mins*

STS-46: Mission Highlights

This features the 12th flight of Atlantis with a crew of seven. Flight objectives included the deployment of the European Recoverable Satellite (Eureca) using the Robot Arm operated by Mission Specialist Claude Nicollier and the first, though unsuccessful, launch of a Tethered Satellite. *50 mins*

STS-54: Mission Highlights

The flight of Endeavour with a crew of five features splendid scenes of the launch of theTracking and Data Relay Satellite (TDRS) against an Earth backdrop and experiments with Biopack. Onboard crew activities include a variety of physical exercises. The video concludes with spectacular EVA and Earth shots. *50 mins*

STS-49 Mission Highlights

The details of this flight by the Shuttle Endeavour, 7-16 May, 1992, are well covered, e.g. the preliminaries of suiting-up, the White Room, entry to orbiter, removal of gantry, count-down, engines start, lift-off, and detailed operations during the flight. A principal aim was to retrieve the Intelsat VI satellite which had previously failed to reach synchronous orbit. Though more difficult than expected, it was achieved and sent on its way. A second aim was to practice basic space station assembly work by Extra-Vehicular Activity (EVA). This was also very successful. The video concludes with an interesting press interview with the crew. *1hr 50 mins*

Giotto - Encounter With Halley

This ESA video covers the history of the famous comet from its earliest sightings to ESA's Giotto mission that flew within 600 km of the icy body in 1986. *56 mins*

Ulysses, The Movie

In this ESA video, superb computer graphics describe the mission of the ESA/NASA solar polar probe launched by the Space Shuttle in October 1990. *26 mins*

A Collection of "The Movies": LA, Earth, Mars & Miranda plus Voyager 2 Neptune Encounter

Created by the Jet Propulsion Laboratory, this video, features four short productions which use satellite/space probe images and supercomputer graphic animation. *17.5 mins*

An extra feature, 'Voyager 2 Neptune Enconter', illustrates the various aspects of Voyager's encounter with Neptune. *29 mins*

Space Shuttle Challenger: Accident & Investigation

On January 28, 1986, the Space Shuttle Challenger exploded 73 seconds after blast-off from the Kennedy Space Center. All seven crew members died. This video documents task force activities and findings and provides a concise, technical explanation of the cause of the Challenger accident. *29 mins*

STS-26: The Retuirn to Flight

This video depicts the highlights of the STS-26 mission, the first launch since the Challenger accident. During the flight, the five-man crew deployed a Tracking and Data Relay Satellite. There is no commentary on STS-26 Highlights, apart from the astronauts' transmissions. The tape is accompanied by a FREE mission guide. *57 mins*

Please send me the following cassette(s): Please Tick

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❒ STS-54: Mission Highlights	£15	(US$27)
❒ SPACE '93 Satellite Link-Up	£9	(US$16)

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Spaceflight

The International Magazine of Space and Astronautics

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Space International

Features

News & Events

Space Miscellany

Front Cover: **UK Space Minister Ian Taylor MP opens the Space Pavilion at the 1994 Farnborough Air Show on 5 September, "Making the public aware of what we are doing is a very important stage in underpinning our space effort", he said.** *Photo:* **CLIVE SIMPSON**

UK Minister Opens Space Pavilion

The British space industry combined forces with the European Space Agency (ESA) to promote a major display at this year's Farnborough Air Show. After several years of dwindling space participation, the general public had for the first time a real opportunity to see what Europe and Britain are doing in space. Under the theme 'Europe - Putting Space to Work', ESA, together with the British National Space Centre (BNSC) and the United Kingdom Industrial Space Committee (UKISC), featured activities inside a large space pavilion.

BY CLIVE SIMPSON
BIS Member

British space minister, Ian Taylor MP, officially opened the space pavilion on 5 September, saying in his address that he was "delighted" ESA had decided to return to Farnborough after an absence of many years.

"It is extremely important they are here and I believe the presence of ESA underlines the very close relationship that we in the British government have with ESA and what it is doing.

"My opening of the pavilion today emphasises the collaboration between ESA and the United Kingdom Industrial Space Committee and the British National Space Centre, and I also welcome all the industrialists here.

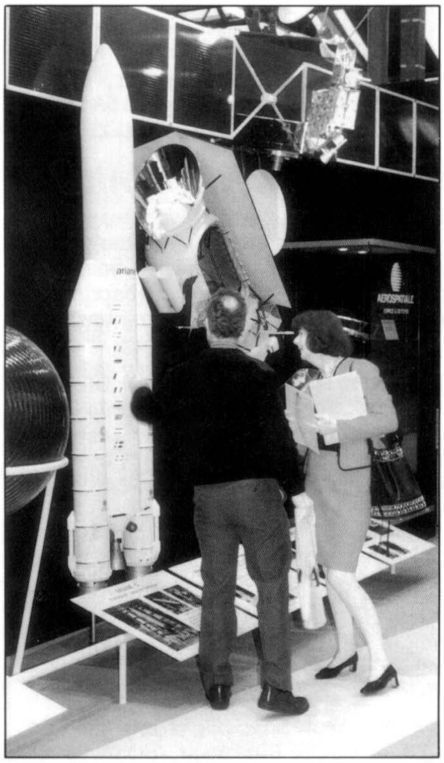
"I would also like to pay tribute to members of the Parliamentary Space Committee. Sir Michael Marshall and the committee have done a very great deal to make sure relationships with the space agency have progressed very well.

"I regard this as a very significant occasion and a unique opportunity for people to see just how much is going on in terms of space activity between ourselves and our European partners.

"It is also timely because towards the end of next year there will be a ministerial meeting of the European Space Agency which will give us the chance to look forward and review where we are going next in terms of our space activities, as well as re-examining our priorities.

"I don't think there is any doubt about the enormous challenges ahead. Some of them we face are very obvious. The whole challenge that lies ahead in terms of the effort, involvement and cost means that there will have to be a restructuring of industry, and that is possibly best shown by the recent merger of BAe Space Systems into Matra Marconi Space. It is certainly one that I welcome, making it the largest space company in Europe. If we can build this sort of company - and Matra Marconi Space will be very much of an equal balance between French and British interests both in terms of activity and employment - I think we will be able to go into the next generation of space research from a strong European base.

"The role of the British National Space Centre is important and I certainly regard it as one of my own high



Other stands at Farnborough also featured space exhibits, among them Aerospatiale of France.

At the UKISC Demonstration inside the Space Pavilion.

priorities as a minister to ensure there is wider recognition of the work of the BNSC.

"One of my tasks as a minister is to persuade people how relevant the activities and work in space are to them. It is so often forgotten how many things that we now take for granted can only be so because of the efforts of ESA and the BNSC. Making the public aware of what we are doing is a very important stage in under-pinning our space effort."

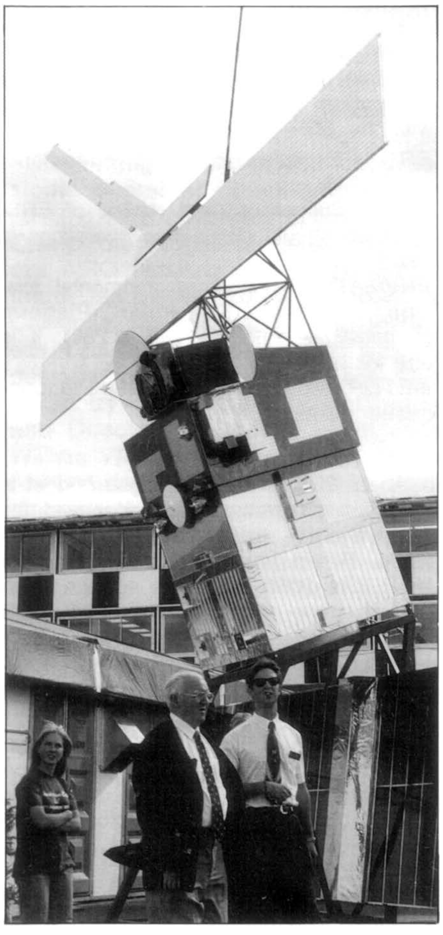
* * *

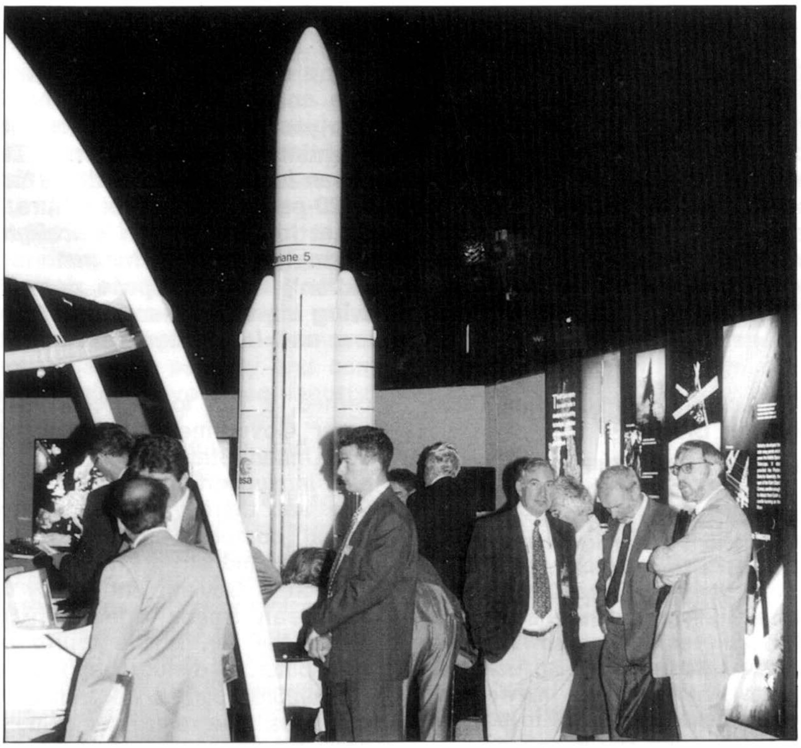
Among the spacecraft on display were models of Envisat, the Ariane 5 launcher, ERS-2, Giotto, Ulysses, SOHO and ISO.

As well as the satellite and launcher models, there were panels and specialised computer demonstrations - based on Earth observation, data utilisation, information system guides and aerospace databases - which allowed both the professional visitor and the general public to get closer to space.

The BNSC also gave the first public demonstrations of its new CD-rom multimedia index 'Britain's Place in Space' which provides a complete overview of the space capabilities of UK firms, schools, universities and research centres, together with a host of other topics.

A model of the ERS satellite added a welcome new feature to the Farnborough skyline.





Inside the Space Pavilion showing the ESA display with a model of Ariane 5.

ESA Backs Manned Programmes

The Director-General of the European Space Agency, Jean-Marie Luton, was also present on the first day of Farnborough 1994. In a speech to industrialists he said: "Britain has always played an influential role in a number of areas of European space research, including science, telecommunications and Earth observation. I hope we will continue to be partners given the challenge that ESA and the European space industry faces.

"You all know the space sector is currently going through an evolutionary phase. In Europe we are having to come to terms with a new political situation and the harsh economic realities. Priorities have also changed, particularly in respect of manned space programmes. Cooperation is now very important. What we have done within ESA over recent years is to adapt our strategy to meet new situations.

"Concerning our obligation to the international space station, we will be providing the Columbus orbital facility. We will also be moving forward with Ariane 5. By the end of September (see right) I am going to sign an industrial contract for the development of a capsule demonstrator to be launched by Ariane 5.

"It is up to us as Europeans to show our determination to remain a strong and credible space power. Britain and its industry has been one of the major players in European space activities. I hope it will remain one of the driving forces behind development".

All photos are by the author. ■

Re-Entry Capsule for ESA

On 30 September, ESA appointed Aerospatiale as the prime contractor to lead a team of 22 companies in nine European countries in the development of a demonstration re-entry capsule. The contract was signed by Jean-Marie Luton, ESA's Director General and Louis Gallois, Chief Executive of Aerospatiale at ESA Headquarters.

The demonstration vehicle, called ARD or Atmospheric Re-entry Demonstrator, is a tangible result of the reorientation of ESA's manned space programme towards affordable concepts and is intended to pave the way for Europe's contribution to the International Space Station programme.

The unmanned ARD capsule, which will measure 2.8 m in diameter and weigh about 3000 kg, has a tight development time-scale being due for launch in April 1996 by Ariane-5. Also on board the Ariane-5 will be a communications satellite for transfer to geostationary orbit while the ARD capsule is in suborbital flight.

The ARD can be considered to be a first step towards a future crew transport vehicle. More specifically its aims are to validate Europe's ability to cope with the aerothermodynamic problems of atmospheric re-entry, demonstrate its mastery of the materials and the measurement techniques involved, and provide operational experience in navigation, guidance and control along a re-entry and recovery trajectory.

Work on the concept of developing a Crew Transport Vehicle (CTV) is currently being carried for ESA in parallel studies by two separate groups of European firms, one headed by Aerospatiale and the other by DASA (Germany). The ARD contract will therefore combine its ongoing technological developments with the work on the CTV concepts.

UK Space Activities 1993-1994

The UK space programme is constrained by a ceiling on expediture and this is turn inhibits new initiatives. One year's annual UK space report therefore inevitably reads like that of a previous year, particularly in its detailing of space projects which by their nature continue over many years. The UK report for 1993-1994, which has recently been issued by the British National Space Centre (BNSC) in the form of a 20-page pictorial brochure, does however have identifiable changes from that for 1992-1993 (*Spaceflight*, October 1993, p.342) apart from its revised format. It is seen, for instance, that as well as international 'space collaboration', that of 'space competitiveness' has gained recognition. Also receiving a worthy mention is 'Technology Transfer' - the diffusion of know-how and innovation across industry and society.

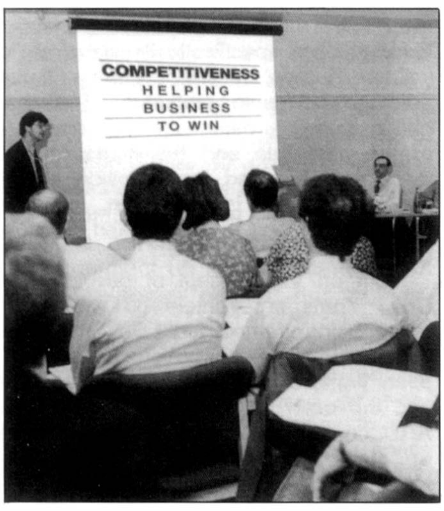
In the words of Derek Davies, Director General BNSC:

> 'The space sector has much to contribute to Government's aim of sharpening UK industry's competitiveness, both directly and by raising awareness of the sector's management expertise, from handling multidisciplinary, international work teams through to space technology transfer across industry.
> To understand our changing world and compete successfully in it, we have much to learn and much to achieve. BNSC is Britain's key to space.'

Satellite Communications have provided the UK with a long-standing opportunity to put space to work and to compete successfully in the global market. Earth Observations may offer a similar long-term prospect and some 50% of the UK space budget is spent in this area. But, in comparison with satellite communications, private funding by industry for Earth observations has been very limited and its commercial viability more difficult to establish. Consequently, in 1992 BNSC set up a programme to demonstrate the value of Earth observation data and then went on to support a number of feasibility studies for which funding is shared with the private sector, examples of which include the monitoring of sugar-beet (with Logica) and of fish stocks (with Vega).

The relative roles of private funding and Government support are hotly debated in many areas of industrial activity but, as far as space is concerned, it has to be recognised that other Governments, notably that of the United States, play a significant part in support of their space industries and thereby in maintaining their global competitiveness.

BNSC liaises closely with industry. BNSC



For UK industry there is the indirect infusion of Government money via the European Space Agency (ESA) to whom the UK is the fourth largest contributor. Sixty-four per cent of the UK 1993/94 budget went on ESA programmes, (the remainder going to the national programme). ESA places most of its contracts with industry in the member states and ensures that each state's contribution attracts a financial return and a share in the space technology spin-offs.

This policy works well so long as there is a close correspondence between ESA programme requirements and those of a member state. in the case of the UK, this is so in the areas of Earth observation, satellite communications and space science. But it is not so in other areas. ESA has an active and developing space launcher programme to which the UK makes a minimal contribution and receives a minimal return, participating in only a small part in the Ariane-4 launcher research and technology programme. At the same time the UK uses Ariane launchers for Skynet and pays costs to ESA which go to benefit space industries in other countries. in the case of ESA's manned space programme, the UK makes no contribution and in consequence there is no UK involvement by either personnel or industry in general.

Since ESA's current policy directions were agreed in 1992, the UK has continued as a long-standing and closely-integrated partner of European space activities. During the last two years, however, geopolitical events have been such that European thinking on its future space role has been, and still is, undergoing critical reassessment. At the next ESA ministers' meeting in September 1995, new policy directions may well be introduced. Until that time, and so long as the Government's ceiling on space expenditure remains, there will be uncertainty within the UK space industry regarding the type of future it can expect.

Derek Davies, Director-General BNSC.

UK Space Funding Sources 1993/1994

DTI Department of Trade & Industry	95.49
MOD Ministry of Defence	7.5
SERC (to 31/3/94) - PPARC Science and Engineering Research Council Particle Physics & Astronomy Research Council	51.12
MET Office Meteorological Office	12.87
NERC Natural Environment Research Council	1.50
DoE Department of the Environment	2.83
Total £m	171.31

Total Spent by Subject

Earth Observation	86.87
Science/microgravity	44.95
Satcoms	16.38
Technology	5.15
Other National	0.48
ESA general	15.90
Space station/transport	1.58
Total £m	171.31

Earth Observation

Britain plays a key role in ESA's new generation of satellites, which started with the ESR-1:

ERS-1: Expected to remain operational until 1995;

ERS-2: Successor (and replica of ERS-1) which should commence operations in 1995;

ENVISAT: First ESA environmental mission to use the Polar Platform (***Spaceflight***, August 1993, p.255). It is due for launch in 1998.

METOP: Meteorological Polar Platform-based mission.

Space Science

About 26% of the UK space budget is spent on programmes to understand the Solar System, the Galaxy and the Universe. Britain helped to conceive ESA's HORIZON 2000 long-term science strategy of space missions. Since last year's UK report was issued, ESA has authorised the following new missions:

Integral - ESA's Gamma-Ray Telescope: To be launched in 2001 (***Spaceflight***, August 1993, p.274);

Rosetta - Cometary Probe: To be launched in 2003. It is currently in the design phase with Southampton University central to its development and committed to its instrumentation;

FIRST - An infra-red telescope to be launched in 2006. ■

World Space Markets Survey

Ten Year Outlook

In all countries, space activity remains almost entirely under government control. Commercial space markets have grown but remain comparatively small, and sometimes correspond to commercially-procured government programmes. International commercial exchanges are limited and mainly concern launch services and communications/broadcasting satellites.

The International Scene in 1994

Introduction

The United States, Russia, Western Europe, Japan and China are the five principal centres for space activity in the world. However, significant differences exist between the civil space budgets of these five leaders and also between the levels to which they have developed military and commercial applications.

The economies of most major industrialised countries grew in real terms throughout the 1980s and then began a slow slide into recession in 1990. Space budgets were directly affected by this slow down in the economic activity, at different times depending on the country. Russia and the United States were the first hit by a reduction in their space budgets, primarily in their military sectors, whereas other countries throughout the world began to be affected from 1993 by a stabilisation, at best; otherwise by a reduction in real terms in their space expenditure. Japan was the only developed country to hold out, but this may change if the economic situation in that country continues to deteriorate.

Budget Levels

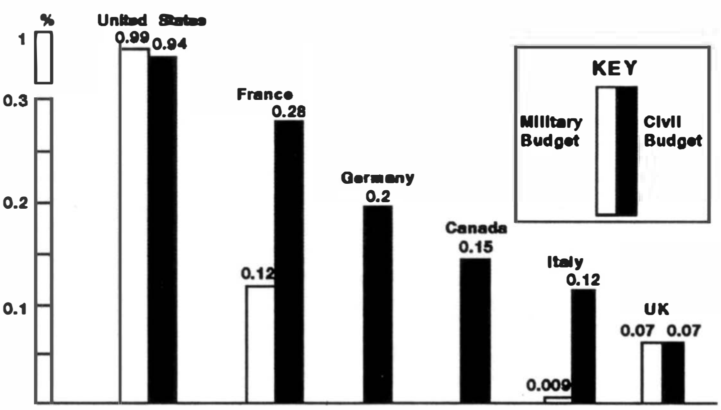
The United States' 1994 space budget is estimated to total $28.95 billion, including $15.1 billion allocated to the Department of Defense (DOD) and $13.45 billion to NASA. Despite a sharp decrease in DOD's space budget in the early 1990s, it is still the world's largest space budget. (It was the vigorous investment in military space systems during the 1980s which allowed the United States to maintain a commanding position in all or most space applications).

The adaptation of the US space programme to budgetary realities has put a stop to the growth in the space budget of the two agencies since 1992 but the DOD's budget could at least pick up again. The budgetary choices that will be made in 1994, with the adoption of the 1995 fiscal year budget, within the context of needing to reduce the federal deficit, will be indicative of the support of the Clinton Administration to space.

By its achievements, the Russian space programme ranks second behind the United States, but the rouble's exchange rate with US$ makes financial comparisons pointless. The Russian Space Agency (RKA) appears to weather economic crisis relatively well given the circumstances. It received for 1994 a budget of Rb 167 billion (corresponding to more than 90% of the civil space expenditure of the Commonwealth of Independent States), compared to Rb 126 billion in 1993. After an 80% fall in 1991, the military space budget is stabilising. It supposedly received an allocation of about Rb 40 billion in 1993, roughly one-third of the civil space programme.

Taken together, Western Europe is the world's third space power in financial terms. The 14 European members of the European Space Agency (ESA) will spend $4.6 billion on civil space programmes in 1994, including $3.3 billion (72%) on ESA programmes, and an estimated $1 billion on military programmes.

space budgets as % of Government expenditures



1989 for Canada, 1990 for UK, 1991 for Italy and the USA, 1992 for France and Germany.

Due to financial difficulties, most European countries are reducing or limiting the growth of their domestic programmes in order to maintain their contribution to ESA.

France remains the leader among ESA member states in 1994, with a civil space budget of $1,572 million, followed by Germany ($1,014 million), Italy ($504 million), Great Britain ($252 million), Belgium ($171 million), The Netherlands (129 million), and Sweden (94 million). These relative positions have not changed in recent years, though growth rates have differed among countries.

Japan's space budget continued to grow in real terms in 1994 to $1.98 billion at 1993 exchange rates, including 78% allocated to the National Space Development Agency (NASDA). Japan has no discernible military space programme.

The Chinese space budget is not publicly known, but it is estimated at $1.3 billion, including $800 million for military programmes, and it has reportedly remained flat for several years with little prospect for growth in the near future.

Four other countries maintain much smaller, but noteworthy space efforts, geared primarily toward applications programmes:

- India, with a 1994 space budget of $230 million, mostly administered by the Indian Space Research Organization (ISRO). Its space activity is vigorous and broadly diversified;
- Canada, with a budget of $409 million in 1994, a peak year in its space spending;
- Brazil, whose space budget is estimated to be stable at about $100 million in 1994, is facing technological and financial difficulties;
- Israel, whose space expenditure is not publicly disclosed, is experiencing difficulties in developing its small satellite/launcher programme.

Sales

Generally speaking, the level of space production in a given country corresponds to its government's space budget. To some extent, this rule is moderated by the state of development of the local commercial space market and by local industry's responsiveness to domestic and foreign demand.

The US space industry is clearly dominant. Though its growth slowed down in recent years, it averaged about 5% in constant annual value over the period 1983-93. According to the Aerospace Industries Association of America, US sales of space equipment and services (including research, development, test and evaluation) totalled $29.188 billion in 1993 (down 2%). A slow growth is expected in 1994, with estimated sales of $29.881 billion, but not enough to compensate for inflation.

By comparison, the European space industry had estimated sales of ECU 2.5 billion in 1992, or 11% of US space sales, reflecting Europe's smaller domestic market. The European commercial market, consisting essentially of communications satellites and their launches, is estimated to amount to ECU 700 million in 1992. The relative importance of this commercial market is greater for European (28%) than for US industry, whose commercial market, valued at $4.86 billion in 1992 by the US Department of Commerce, represented 16% of industry sales. The export market accounted for between 15% and 20% of European industry sales in 1992, but remains very highly dependent on the success of one company, Arianespace, in the increasingly competitive commercial launch market.

The Japanese space industry had sales of Y366.7 billion in fiscal year 1992 (up 24.5% from 1991), including a large ground segment component, corresponding to 33% of total sales. Exports of ground segment hardware formed 63.5% of Japanese space equipment exports in 1992. The imbalance in industry size is huge compared with the USA (a 1 to 15 ratio) and small compared with Europe (a 1 to 1.6 ratio).

The Space Applications Market

Satellite Communications, Largest Market for Space Technology

Commercial satellite communications has remained on the upswing after the low reached in 1985-86. Activity will remain intense over the next two years, with 26 satellites scheduled for launch in 1995 and 23 in 1996 (excluding Russian-made satellites, for which launch manifests are not known with accuracy). These levels are so high that some launch service providers are running out of flight opportunities; this and other bottlenecks make it likely that some launches will slip into later years. However, launch activity is expected to decline substantially thereafter, to 13 satellites in 1997 and 1998, and 8 in 1999.

The current activity is largely a reflection of the growth which marked satellite communications in the first half of the 1980s; out of the 83 spacecraft awaiting launch, 49% or 41 satellites, were ordered by existing operators to replace older models in their constellation, the remainder being new private or domestic systems. Over the longer term, from 1992-2004, the market is estimated at 178 satellites and valued at $16 billion (1992 $), excluding Russian-made satellites.

Slower Growth of Satellite Capacity

A slower growth of satellite capacity is now to be expected, being the product of several trends. In particular, the competition of terrestrial facilities such as fibre optic networks is clearly hurting fixed satellite services. In seeking to deflate the transponder overcapacity which has resulted, US and Canadian operators can be expected to follow demand more cautiously. Up to the end of 1998, the total C-band and Ku-band transponder count is expected to decrease in the US domestic market, and to take a one-time 25% cut in 1995 in Canada.

Russia plans to entirely renew its geostationary satellite fleet during the 1990s, its transponder count growing at an annual rate of 17% based on authorised government programmes and by up to 21% if the more uncertain projects of emerging private operators are taken into account. Russia could experience even stronger growth at the turn of the century, as the country's economic situation improves and given the government's telecommunications upgrade plans which rely heavily on satellite applications, but this market should long remain speculative given the scope of other needs to be satisfied and the dominant position of the local satellite industry.

As the cost of fibre optics continues to decrease and its capabilities to improve, satellites may not indefinitely keep their place at the side of cable systems, either for video distribution, trans-oceanic communications or even shorter-haul data communications. Investment in fibre networks now exceeds investment in satellite constellations in the US and Japan and on trans-Atlantic and trans-Pacific trunk routes, it is the reverse of the situation of the early 1980s.

Growth Depends on Introduction of New Services

The continuing migration of point-to-point voice and data to fibre optic cables means that market growth will largely depend on the introduction of new satellites services such as Direct Broadcasting by Satellite (DBS) and mobile satellite services.

Almost 20 years after NASA's MSAT-X proposal was filed with the US Federal Communications Commission, mobile satellite services have finally become a significant market. In addition to six geostationary satellites on firm order and six under consideration, a number of proposals have been tabled for non-geostationary systems, with a total inventory of up to 268 satellites to be launched over 1995-2000. Regulatory and financial arrangements progressed sufficiently in 1993-94 to make the 2-3 most plausible contenders easier to discern; the uncertainty which remains on technical feasibility and on the systems' markets themselves, can probably be dispelled only through actual experience.

Whether these new services develop successfully will depend less on space technology than on consumers on the ground. In particular, the mobiles market is becoming saturated with new cellular and satellite technologies, among which there will certainly be more losers than winners. Satellite services also appear increasingly constrained by crowding in the electromagnetic spectrum, which resulted at WARC '92 in footnotes making some frequency allocations effective only as late as 2007, and along the geostationary orbit, in particular over Europe and the Pacific basin.

Dominance of American Suppliers

US manufacturers were prime contractors for 77.4% of the 279 civilian communications satellites delivered or on firm order from 1972 to April 1994. As of April 1994, US prime contractors had 53 satellites on order or awaiting launch, over 73% of the world's total backlog. In value, US suppliers lost only about one-third of their market share from the early 1980s to European suppliers and to a lesser extent, Canadian and Japanese manufacturers, achieving a 69.7% market share outside the former USSR, China and India, corresponding to a committed market estimated at $12.15 billion. The two companies which have been market leaders since the early 1970s only appear to have become even more dominant.

The market share of European prime contractors increased slightly from 23.5% of the second-generation market to 25.2% of the third-generation market captured as of April 1994. However, this figure is likely to decrease, as European manufacturers are currently living largely off their backlogs, and these will have almost entirely deflated by 1994 without new orders. European companies were prime contractors for only 11.1% of the satellites to be delivered as of April 1994, with seven spacecraft on order. The high price of many of these satellites contributed in part to building up Europe's market share in value.

Earth Observation, Still Driven by Governments

Earth observation was chronologically the second satellite application to emerge, after communications, but it only began to develop as a market in the mid 1980s when American, French and Soviet commercial operators went on-stream.

Meteorological satellites are even further from the market and are financed by national and regional meteorological organisations, e.g. the National Weather Service, a division of NOAA in the United States; Roshgydromet in Russia; the Japan Meteorological Agency; Eumetsat in Europe; and the India Meteorological Department. The cost of procuring and operating satellites and the processing of their complex data account for a growing share of meteorological agency budgets. These agencies are finding it difficult to finance or expand their satellite systems, because space technology is costly and risky, and because satellite budgets have always been underestimated. However, the economic efficiency of weather satellites, gauged in terms of savings achieved in all user sectors in relation to overall cost (satellite manufacture, launch and operations) is the highest of all space applications. To recover a part of their costs, meteorological agencies are developing value added services, in competition with a growing private sector.

Data generated by the meteorological satellite systems in operations in the United States, Europe, Russia, India and Japan are exchanged on a cost-free basis as a global public service through the World Meteorological Organization (WMO). Russia and China could launch their long-awaited first geostationary meteorological satellites in 1994 or 1995, thus enriching the data collection of the World Weather Watch and Global Atmospheric Research programmes of the WMO.

The satellite market for Earth observation is relatively closed. Satellite programmes are generally financed by space agencies and government operating agencies. The industrial capabilities required to develop advanced Earth observation payloads are not widespread. The market, excluding Russia and China, averages two satellites per year in the 1994-2003 timeframe for civilian meteorological systems and two to three and a half per year for civilian remote sensing. The range in the number of remote sensing systems to be built over the next ten years is related to the governments' ability to finance large systems for global environmental observation and to the realisation of various US initiatives for private remote sensing.

Remote sensing evolved over the 1980s from a situation of *de facto* US government monopoly with the requirement that all data be distributed almost cost-free and on a non-discriminatory basis to one of growing competition between commercial systems. As the study of global environmental change becomes a high-level priority for governments in the United States, Western Europe and Japan, any earlier emphasis on the priva-

tisation of government-owned satellite systems appears to have been toned down. At the same time, several projects to develop private Earth observation satellite systems have surfaced since 1992 in the US, principally targeting the high-resolution imagery market. As of early 1994, their progress toward implementation had been slow, but considering the various blocking factors they have encountered (late Administration policy definition, raising of capital, technical choices), their emergence is real.

Though sales of data from remote sensing satellite systems have grown sharply in recent years, most sales are generated by a large network of value-added service companies, providing data processing, analysis and interpretation services. The availability of digital satellite data and compact, affordable workstations has enabled the image processing systems, software and services sector to grow vigorously, generating six times the revenue of satellite image sales. The US Department of Commerce estimates the worldwide satellite remote sensing market, excluding the space segment, to be worth $400 million and potentially more than $2 billion by the year 2000. The satellite image market does not lend itself to easy assessment, as the two principal operators in the sector, Earth Observation Satellite Co. (Eosat) and Spot Image SA, have licensed a number of regional distributors. On the whole, fees collected from these distributors, and direct sales by Eosat and Spot Image, are estimated to have amounted to about $65 million in 1993. This figure is 15% lower than in 1992, because of limited space capability (aging Landsat-5 and recorder anomaly on Spot-2) and a stagnant demand.

Applications of radar remote sensing remain largely experimental to this day, with two satellites (ERS and JERS) in operation. Commercial performance of the Russian Almaz-1A satellite was disappointing with total sales under $1 million by the time the satellite was taken out of service (year-end 1992). However, Almaz-1A was primarily intended to be a research asset to the Soviet scientific community. Radarsat, to be launched in 1995, will be the first operational radar satellite, commercially operated by Radarsat International Inc (RSI).

Microgravity Research, Drop In Agency Support

After telecommunications and remote sensing, use of the microgravity environment is the third major area of potential space applications. however, unlike the telecommunications market, which is considered "mature", and Earth observation, which is entering the marketing phase, space experimentation is still at the stage of basic scientific research, and not applications research. Thousands of additional test-hours will be needed to achieve reproducibility and process control in order to define the basic economic criteria for the commercial operation of systems using microgravity.

Research in the field began with testing programmes on sounding rockets (SPAR in the United States, TEXUS in Germany and TT500 in Japan), which served to define experiments. The scope of the experiments was then broadened through the utilisation of the Space Shuttle, around which all instruments for microgravity research have been designed (MAUS, SPAS, Spacelab). Consequently, this area of space applications was the hardest hit by the grounding of the Space Shuttle fleet and by the limitations imposed on their subsequent use.

Considering the rare flight opportunities, conventional methods involving parabolic flights and sounding rockets have staged a comeback, and experimenters, especially in Europe, have turned toward the new Chinese and Russian supply of recoverable satellites. Similarly, the lack of infrastructure for long-term experiments (apart from the Mir station) has led to the development of new systems, Eureca in Europe (again dependent on the Shuttle) and Comet in the USA. However, these systems are facing funding problems.

Indeed, after a sharp rise in expenses for microgravity research during recent years, the space agencies, confronted with budget constraints, are now less disposed to fund it, and industry is not yet ready to take it over in spite of a variety of incentives. There seems at present to be limited room for promoters of commercial experimentation systems. The commercial programmes in progress, derived from existing technology and often financed from public funds (Spacehab, Westar), have not aroused significant interest up to now.

Commercial Launch Services

Introduction

Space transportation has developed into a sizeable and dynamic industry, though one which obviously depends entirely on the progress of satellite applications.

A total of 3,575 successful launches were carried out worldwide from 1957 to the end of 1993, including 2,416 by the Soviet Union, 1,005 by the United States, 57 by Europe, 45 by Japan, 34 by China, four by India, two by Israel and one by Australia. Over 70% of all launches still relate to government programmes, either for military or scientific applications.

The number of launches successfully executed worldwide stabilised from the mid-1960s to 1990 at a level of about 100-130 per year. Since 1991, that figure has been lower than 100, with a marked decrease to 80 in 1993 which can be entirely attributed to the slowdown of space activities in Russia, whose share of the world's launch record declined continuously from 1987. A range of 95 to 101 launches are planned for 1994 with an increase in non-US and non-Russian launches.

Factors Driving Commercial Launch Demand to GTO

Satellite technology development reduces launch demand: technology has allowed the size and capacity of communications satellites to continually in-

crease. As a result, fewer satellites are required to handle the same amount of traffic.

Growth in satellite mass has been continuous since 1970 as a result of both operators' needs for increasingly heavy satellites and the availability of more powerful launchers. The launch mass of commercial satellites has grown steadily from an average of 750 kg in the early 1970s to an average of 1,750 kg by 1990. This trend has continued with recent satellite orders, pointing to an average launch mass of about 3,000 kg by 1996. While traffic was dominated from 1980-93 by satellites in the 800-2,200 kg class, more than half of those scheduled for launch from 1994-97 have a launch mass between 2,500-3,750 kg. In particular, Intelsat's last three generations of satellites (Intelsat 6, 7 and 8) have launch masses ranging from 3,500-4,600 kg.

More reliable technology and more accurate launch vehicles have allowed the operational lifetime of satellites to increase, on average, by two years from each generation to the next. Thus, the 6-8 years lifetime of the first-generation domestic satellites has increased to 10-12 years for most satellites launched over the past years. Over the next ten years, the lifetime range could increase to 14-16 years, though some operators consider that technical obsolescence could reduce the advantage of operating satellites beyond 14 years.

Powerful launch vehicles and large order books have made dual payload launches practical, to the point where they represented 59% of Ariane commercial flights from 1984-93. Arianespace was the first launch service provider to market dual launches. In the years to come, the introduction of Ariane 5 and the likely marketing of Proton, Long March and H-2 with this capability should continue to attract satellite operators with price reduction and additional launch opportunities despite a risk of delay to them by a co-passenger.

Low Earth Orbit: Big Satellites for Earth Observation and Potentially Small Satellites for Communications

The launch market for civil application satellites in low Earth orbit (LEO) is financed by Government agencies and currently represents a small number of satellites per year (about ten per year worldwide). Developing concerns over the management of the environment and the monitoring of Global Change on the planet will result in a growth in the launch of meteorological and Earth observation

satellites over the next ten years. From an average of 1.5 satellites launched per year over the 1970s and the 1980s, excluding the CIS and China, the number should grow to 3.5 over 1994-2003, assuming that the funding for such programmes is provided over the long term to ensure the continuity of observation.

The launch market into LEO also includes about 250 small payloads with launch masses between 100 and 1,000 kg that were launched over 1984-93, including 66% in the CIS and 20% in the United States. Excluding USSR/CIS, 64% of the 85 small satellites were launched by medium and heavy launch vehicles, as auxiliary passengers or in multiple launch configurations.

Until now, the launch market of small payloads into LEO has been entirely for governmental applications with a distribution dominated by scientific missions (34 satellites out of 85 launched excluding USSR/CIS, i.e. 40%). Earth observation and meteorology represented 22% of the market, only a few percent more than telecommunications or their military (or classified) missions (about 19% each).

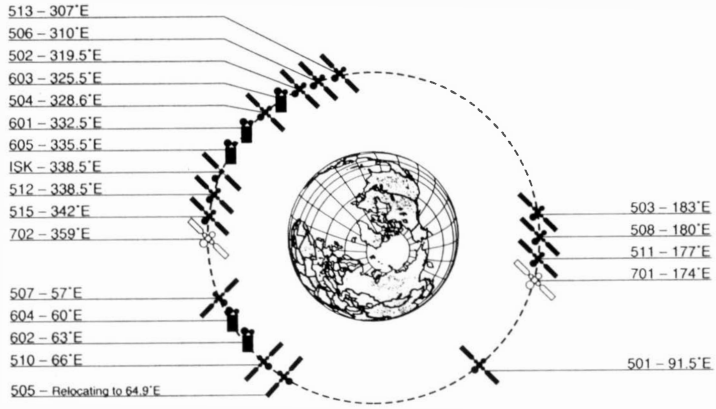
At the end of the 1980s, several factors encouraged a proliferation of projects calling for the deployment of small satellites into LEO, sometimes in very large numbers, principally for mobile communications and Earth observation applications. Mosaics of LEO communications satellites would allow services to be patterned more finely for local markets, with a larger footprint and higher frequency efficiency than large geostationary satellites, while enabling small, low-power mobile user terminals. This potential market then served to justify many small launcher projects based on a large number of satellites with identical characteristics. But the majority of operators with projects for small satellite constellations in LEO for communications have already dismissed the use of small dedicated launchers to orbit their initial systems. They are now even considering the use of heavier launchers for constellation replenishment by groups of two or more satellites.

On average, the world market for small satellites to be launched by small launchers over the next ten years could represent 27 launches per year for government programmes and 1 to 5 launches per year for commercial programmes. In addition, at least 150 small satellites should be launched by heavier ELVs during the second half of the 1990s to implement and maintain large constellations in LEO, principally for mobile communications applications.

A significant growth of the small satellite launch market could occur only with a strong price decrease, allowing small launchers to be comparable to heavy launchers in terms of specific price (price per kg of payload), i.e. less than \$1.5 million per 100 kg, and ideally around \$1 million per 100 kg.

Based on the 1994 edition of World Space Markets Survey, Ten Year Outlook *prepared by Euroconsult, Paris.*

INTELSAT Satellites in Orbit, August 1994



The Intelsat 702 satellite began commercial service on 13 August bringing the capabilities of this newest generation of spacecraft to Africa, Europe, the Indian sub-continent, the Middle East and North and South America. Intelsat 702 is strategically located at 359°E where it serves as the only direct one-hop communications link between the Indian sub-continent and North and South America. A further 13 Intelsat satellites are scheduled for launch before the end of 1996.

On 22 August, the Republic of Kazakhstan joined Intelsat as its 134th member nation.

Recorders for ERS-2

The UK firm Penny & Giles Data Systems, based in Wells, Somerset has received a contract to supply two high density digital data recorders to the ESA satellite tracking station at Kiruna in northern Sweden. Four similar units already installed at the site have been used to capture data from ERS-1 since its launch in July 1991. The new recorders will provide additional capacity when ERS-2 goes into service early in 1995 and will bring to 46 the number of Penny & Giles recorders being used to capture and process ERS-1/ERS-2 data, making the integrated network the largest of its kind.

Sugar-beet Yields

Throughout northern Europe there is a need for sugar-beet crop forecasting since farmers and industrial processors use a quota system to manage production. A second reason is that yields vary considerably from area to area and from year to year. Processors need forecasts to help manage the logistics of harvesting and processing (personnel, machines, transport, raw materials, etc).

Logica Space and Communications Ltd have a contract, funded jointly by BNSC and British Sugar Plc, to produce early forecasts of sugar-beet yields in England. Their experimental programme, which began in 1993, runs until 1995 and uses Spot multispectral imagery acquired during the growing season to increase the size of representative samples previously acquired by helicopter thereby enabling specialists to monitor much larger areas. This considerably improves the accuracy of yield forecasts.

Spot Image is handling satellite acquisition programming in close coordination with the National Remote Sensing Centre Limited (NRSCL), its main distributor in the United Kingdom.

The cost of the satellite data is expected to amount to less than 5% of the savings to the British sugar-beet industry.

After several years of steadily increasing Spot sales, NRSCL's revenues from Spot jumped a further 15% in 1993.

On Sale at Harrods

Harrods, the world-famous department store in Knightsbridge, London, has just started selling the ultimate in mobile phones. For £12,500, the Inmarsat-M briefcase satellite telephone enables globetrotters to make instant calls to and from almost anywhere on Earth.

The caller simply opens the lid of the briefcase and pulls out the telephone. The lid, which doubles up as the antenna, is directed at one of four Inmarsat satellites parked in orbit. The number is then dialled in the normal way and the call is beamed via the Inmarsat spacecraft back down into the international telephone network.

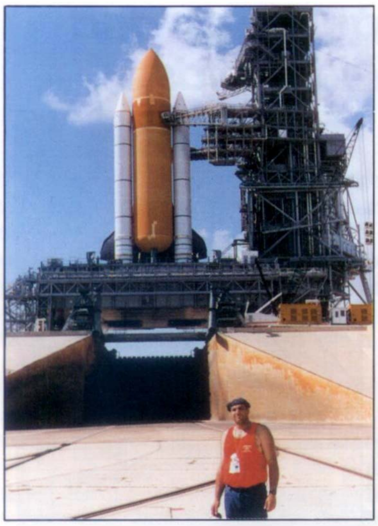
Arctic Sea Ice

Navigation in the Arctic has historically relied on ship-based observations and, more recently, on ice charts derived manually from optical and infra-red satellite images. GEC-Marconi Research Centre, Stanmore, Middx, UK is leading a demonstration in which a survey ship is supplied with sea ice charts derived from radar images acquired by the ERS-1 satellite. These images have much improved resolution over optical and infra-red images, and have the important advantage of not being obscured by cloud cover.

ESA-Greece Cooperation

On 4 July a Cooperation Agreement between ESA and the Government of Greece was signed in Athens for a period of five years with the possibility of renewal.

ESA has recently agreed to provide consultancy support to the Greek Ministry of Transport and Communications with the Hellas-Sat project.



Spaceflight contributor Pete Gualtieri is 'on site' at launch pad 39B soon after the arrival of STS-64 on 19 August. Photo taken by: ANDREW KLAUSMAN, LORAL SYSTEMS

Taking a Close Look at STS-64

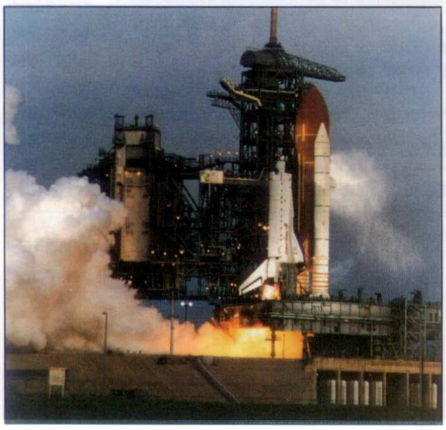
with Pete Gualtieri

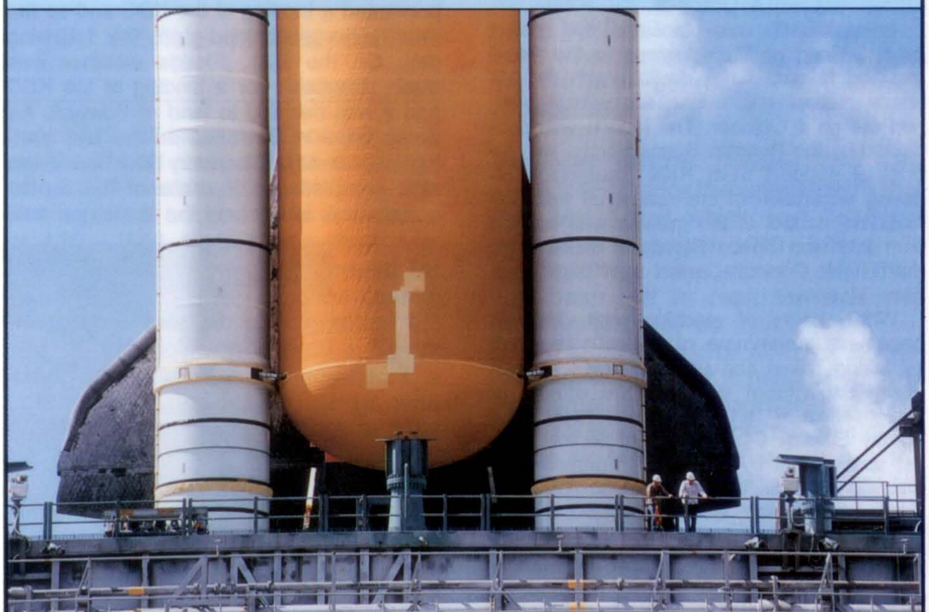
Upper right: A close-up of the External Tank (ET) hydrogen vent line Access Arm. When it retracts, it leaves behind the pad-to-tank umbilicals which release at liftoff and fall back against the tower, where a curtain of water protects them from engine flame. In the picture below of the STS-68 aborted launch, this water spray can be seen coming from behind the ET.

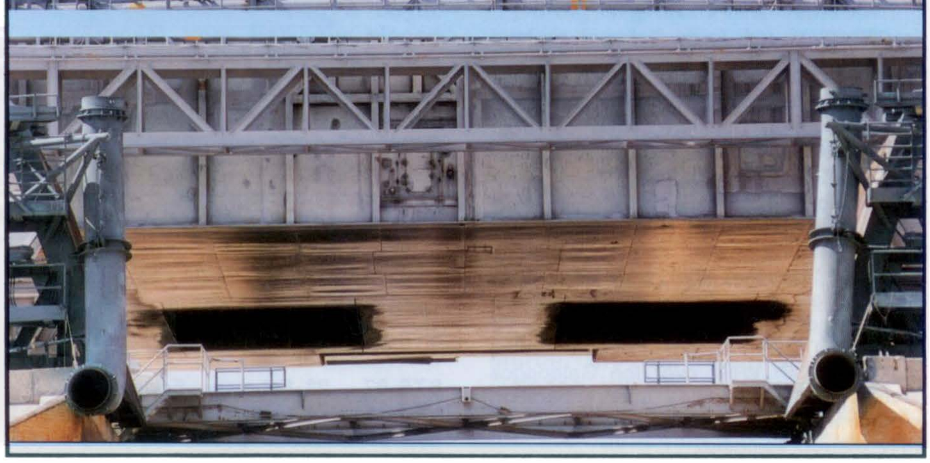
Middle right: The lower attach points of the boosters to the ET can easily be seen in this photo. Along the outer edge of each booster runs the self-destruct prima cord. Also to be seen are the underside of Discovery's wings on either side of the boosters. The texture of the sprayed-on insulation on the ET may be noted. In the near vicinity of the workers at the railings are the 12-foot rainbirds used to spray the launch platform with water. The two holes through the pad *(Lower right)* are under each of the solid rocket boosters.

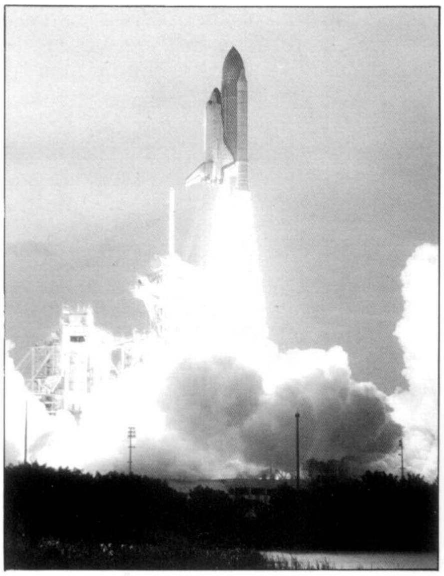
All photos and information on this page are courtesy: PETER GUALTIERI, WEST KENTUCKY NEWS.

STS-68: It is one minute before sunrise on 18 August and searchlights illuminate the rocket as Endeavour's main engines roar into life. But at T-1.9s the mission is aborted by an engine cut-off. This shot was taken 0.1 s before cut-off.









Lift-off of Discovery on mission STS-64 at 6:23 pm EDT on 9 September.
PETER GUALTIERI/WEST KENTUCKY NEWS

ESA Astronaut Flies to Mir

ESA astronaut Ulf Merbold of Germany, a veteran of two US shuttle missions and Russian cosmonauts Aleksandr Viktorenko and Elena Kondakova lifted off by Soyuz rocket from the Baikonur Cosmodrome on time at 23:42 CET on 4 October.

Soyuz TM-20 was placed in the correct orbit, inclined at 51.6 degrees to the equator, and headed for a docking with the Mir space station which was successfully carried out on 6 October. The launch was conducted by the Russian Space Forces with industrial support from RKK Energiya. Following separation of the spacecraft from the launcher, control of the mission was handed over from the Space Forces in Baikonur to the Flight Control Centre at Kaliningrad, near Moscow.

Within hours of reaching orbit, Merbold began his programme of scientific research by taking saliva and urine samples as part of an experiment to study the effects of "weightlessness" on the human body. The 30-day Euromir 94 mission will be the longest space flight by a western European astronaut. Experimenters will monitor the mission's progress from several remote centres in Europe, linked to the Flight Control Centre by satellite.

Arianespace Flight 67

TELSTAR 402 Launched and Lost

Flight 67 of an Ariane 42L launch vehicle, the version equipped with two liquid-propellant strap-on boosters, lifted off from the Space Center in Kourou, French Guiana, on 8 September 1994.

Its payload, TELSTAR 402, was the second in a new generation of satellites built by Martin Marietta Astro Space. Weighing 3,331 kg at launch it would have been operated by New Jersey-based AT&T and provided telecommunications data and TV programme transmissions from its orbital position at 89° West over the Galapagos Islands. But ten minutes after separation contact was lost after the satellite apparently started spinning.

Two September Launches and Shuttle Schedule Holds

After a two-hour delay to avoid stormy weather, the space shuttle Discovery lifted off at 6:22:35 pm EDT on 9 September for a 10-day mission (STS-64) highlighted by atmospheric research, a satellite launch and a two-man spacewalk to test an emergency jet backpack.

Throughout the mission, an experimental laser system mounted on Discovery's cargo bay operated to determine its ability to gather useful data about the atmosphere (see ***Spaceflight***, August 1994, p.262). Other research planned during Discovery's flight included operation of a robotic materials processing furnace and tests to determine how the shuttle's manoeuvring jets might affect solar arrays or other space station components during docking procedures. The clip-on jet pack to be tested was designed to give space station construction workers a way to rescue themselves should they slip free of safety tethers while the shuttle is docked and unable to come to their rescue.

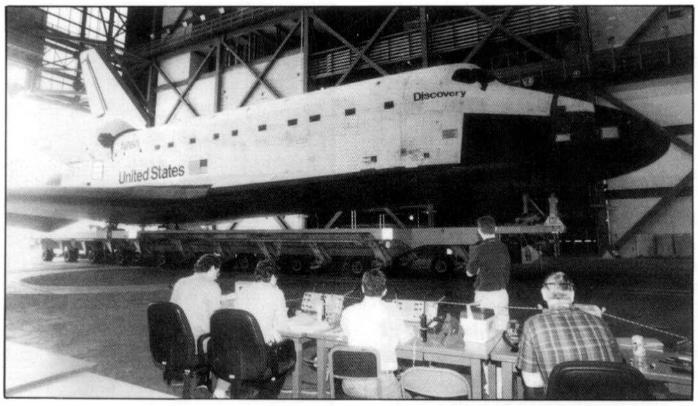
To be launched from the orbiter was a small satellite equipped with instruments to study the solar wind and then be hauled back aboard.

On 19 September the day scheduled for re-entry, thunderstorms and low cloud prevented a landing at the KSC and so the return was postponed until the following day. On the 20th, Florida weather was again unsuitable for a landing at the KSC and it was decided to land at Edwards Air Force Base in California on the first landing opportunity. Discovery touched down after completing 177 orbits of the Earth.

Leading the departure from the Operations and Checkout Building are Mission Commander Richard N. Richards (front left) and Pilot L. Blaine Hammond Jr., Behind (from left to right) are Mission Specialists Mark C. Lee, Carl J. Meade, Dr J.M. Linenger and Susan J. Helms. NASA

Ten days later came the launch on time at 7:16 am EDT on 30 September of Endeavour on mission STS-68. Endeavour had been fitted with a fresh set of three main engines following the trouble that led to a launch pad abort six weeks previously. Its main payload was the Space Radar Laboratory for mapping Earth surface features which had previously flown in Endeavour on mission STS-59 in April 1994. By comparing maps from the two missions, seasonal changes in vegetation and other surface procedures are to be studied.

Detailed reports of the STS-64 and STS-68 missions are due to appear in forthcoming issues.



Discovery is rolled into the Vehicle Assembly Building (VAB) from the Orbiter Processing Facility. In the VAB it spent five days being mated with the external tank and twin solid rocket booster assembly. NASA

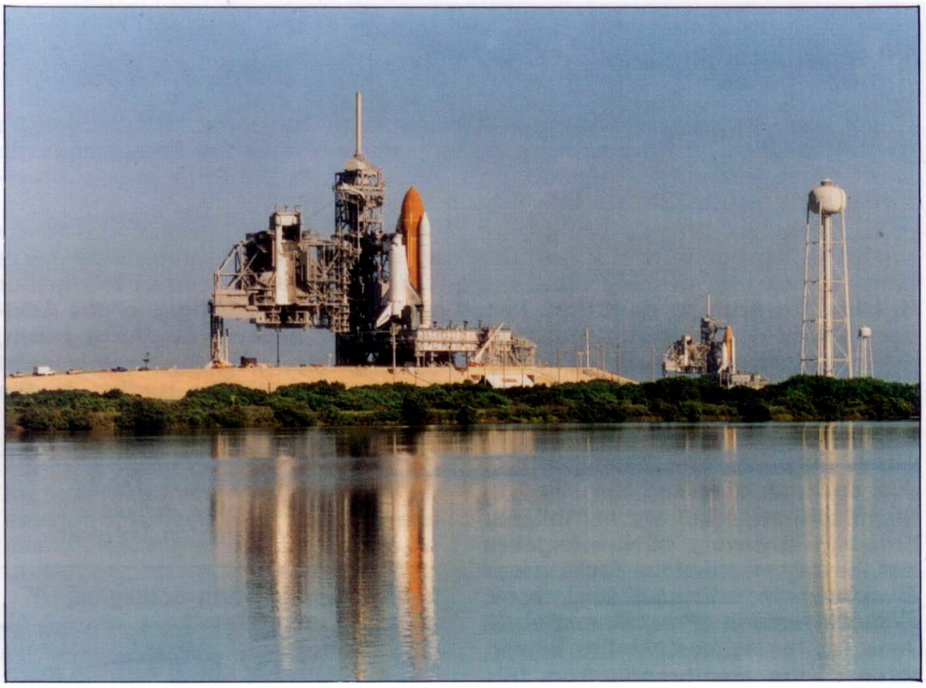
Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-66	3 November	Atlantis	10 Days	Atlas-3, Crista-SPAS, SSBUV/A	57.0
1995					
STS-63	2 February	Discovery	8 Days	Spacehab-3, Spartan-204, CGP/Oderacs-2	51.6
STS-67	23 February	Endeavour	13 Days	ASTRO-2	28.5
STS-71	24 May	Atlantis	9+1 Days	Mir-01 Mission	51.6
STS-70	July	Discovery	5 Days	TDRS-G	28.5

Seen on the Launch Pad

Selected Photos

At KSC



A rare shot - two space shuttles on the two Complex 39 launch pads at the same time. The shot was taken on the morning after Endeavour's aborted launch on 18 August. Endeavour stands on Pad 39A in the foreground and in the background stands Discovery rolled out earlier that morning in readiness for its 19th flight on mission STS-64.

On the right are the two 290-foot high water tanks adjacent to each pad. Their use is primarily for sound suppression being emptied in 20s of 1,135,650 litres through seven-foot pipes.

In the event of an on-pad abort, as with Endeavour, the tanks supply a 'Post-Shutdown Engine Deluge' to cool the aft end of the orbiter.

PETER QUALTIERI, WEST KENTUCKY NEWS

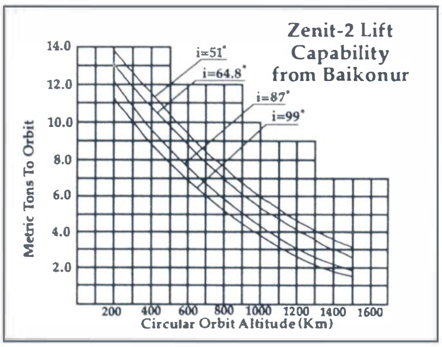
At Baikonur

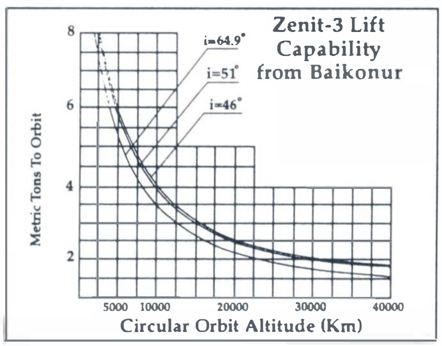
The Zenit-Baikonur launch facility is known for its automated pre-launch procedures (*Spaceflight*, October 1994, p.326). The launch vehicle is horizontally integrated and transported to the launch pad where it is automatically mated with an umbilical tower as our photo shows and pre-launch checks are carried out without human interaction.

Zenit at Baikonur.

The Zenit rocket utilizes the RD-170 engine described in ***Spaceflight***, September 1994, p. 321. The kerosene and liquid oxygen propellants use centralised combustion chambers with four throttle-controlled and gimballed exhaust nozzles for an ultra-smooth payload ride.

The Zenit-2 configuration offers LEO and MEO delivery of payloads into circular or elliptical trajectories. Zenit-3, using the TDK-DM upper stage, provides delivery on orbit for geostationary payloads.





Zenit photo and information are courtesy: JOHN ROSSIE, TERRA FIRMA TECHNOLOGIES

At Cape Canaveral

The launch site of America's first satellite launches has been visited by Tomas Pribyl from Brno, Czech Republic who writes:

> Not so long ago I visited the Air Force Space Museum at Cape Canaveral, Florida, where I saw Launch Complex 26. From its launch Pad A on the night of January 31, 1958, the first "Made in USA" satellite Explorer-1 was placed into Earth orbit. But today's complex 26 is only a full-scale model of the original, because the original service tower has been dismantled.
>
> If you want to have a souvenir of America's first space flight, you can buy fragments of metal from the service tower of the original Complex 26. For one US-dollar you get one fragment and a certificate of origin.

The early days of the US space programme became dominated by America's struggle to gain access to space and catch up on the lead of the Soviet Union. The role of internal US space policy in forming the events of 1955 to 1958 makes a fascinating story and *Dwayne Day* brings new light to bear on the subject in an article overleaf.

Launch Complex 26, Cape Canaveral.

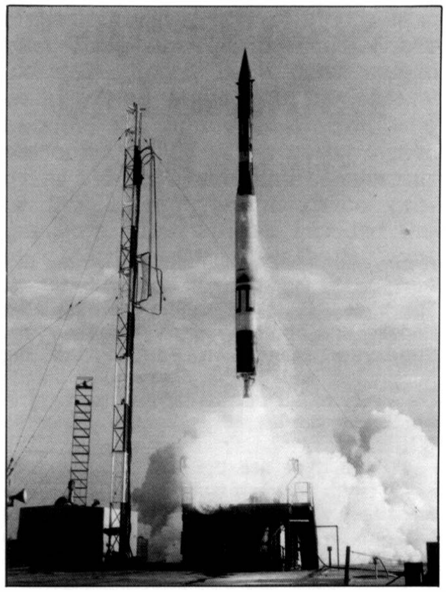
TOMAS PRIBYL

Early Space Policy

New Revelations About the American Satellite Programme Before Sputnik

Eisenhower biographer William Ewald called it "the most fateful decision of his presidency." He was referring to a decision that the President made on or shortly after 12 July 1956, on whether or not the Army should be allowed to launch a satellite into orbit in 1956 or 1957.

The Navy was already working on a plan to launch a satellite aboard its untested Vanguard rocket for the International Geophysical Year (IGY) either in late 1957 or early 1958. The question had been posed as to whether to allow the Army to do it first. Based on the recommendations of the Advisory Group on Special Capabilities, Eisenhower decided no. As a result, Sputnik destroyed much of his domestic agenda, resulting in increased spending on defence, science, education, and eventually leading to the creation of NASA.



Vanguard lifts off from the Cape on 17 March 1958 to orbit the Vanguard 1 satellite. Previous Vanguard failures and Sputnik's success discredited Eisenhower's policy decision. NASA

BY DWAYNE A. DAY
Space Policy Institute
George Washington University

Until June of 1994, the records of this decision remained classified in the Eisenhower Library in Abilene, Kansas. They were all but forgotten and the only record of the decision was Ewald's uncited reference in his book, *Eisenhower the President*. But in June, at the request of the author, three of the memoranda from this decision were finally declassified. These memoranda are excerpted below. All words printed in italics here were underlined by hand in the original documents and apparently made by Deputy Secretary of Defense Reuben B. Robertson, Jr. They provide a fascinating glimpse into how the decision was made and help to further clarify how the United States allowed the Soviet Union to achieve one of its biggest propaganda coups in history.

Advice from the 'Vanguard Camp'

On 22 June 1956, in a memorandum to Charles C. Furnas, Assistant Secretary of Defense for Research and Development, Homer J. Stewart, who was Chairman of the Advisory Group on Special Capabilities, reported the results of two meetings held by the Group in late April. He reported that although Project Vanguard was suffering some minor setbacks and was short of highly capable people, in general the project was on a satisfactory schedule and "one or more scientific satellites can be successfully placed in orbit during the IGY."

But more interestingly, the two-page memorandum stated,

"Redstone re-entry vehicle No. 29, now scheduled for firing in January 1957, apparently will be technically capable of placing a 17 pound payload consisting principally of radio beacons and doppler-equipment in a 200-mile orbit, even with the degradation in performance below the present design figures which might reasonably be expected, but without any appreciable further margin. This capability will depend upon successful accomplishment of several developments, such as the use of a new fuel in the Redstone booster, and the spinning cluster of fifteen solid propellant motors. The probability of success of this single flight cannot be reliably predicted now, but it would doubtless be less than 50 per cent."

The memorandum continued,

"*In any case, such a single flight would not fulfil the Nation's commitment for the International Geophysical year* [sic] because it would have to be made before the beginning of that period. Adequate tracking and observation equipment for the scientific utilization of results would not be available at this time. Moreover, any announcement of such a flight (or worse, any leakage of information if no prior announcement were made) would seriously compromise the strong moral position internationally which the United States presently holds in the IGY due to its past frank and open acts and announcements as respects VANGUARD."

The memo mentioned that a Redstone could be used as a backup later in 1957 if Vanguard fell behind schedule and that No. 29 was the only vehicle which could be used without interference in the Redstone programme. Finally, the memo concluded,

"*At the present time, therefore, the Group does not recommend activating a satellite program based on the Redstone missile, but will reconsider this question and the possibilities* of the ICBM program at its subsequent meetings when the critical items of the VANGUARD program are further advanced."

The memorandum was stamped "Secret" but there is some doubt that it was actually written in May 1956 and not June. It is rare for a report of a meeting to be written two months after the meeting. The memo also mentions the Group's upcoming meeting on 19 and 20 June concerning the propulsion systems for Vanguard and invites contractor representatives to attend this meeting, which would already have happened by the time the memo was written. The 22 June date may be a typo.

Advice from the 'Military Camp'

A second memorandum, this one from E.V. Murphree, Special Assistant for Guided Missiles, to Reuben B. Robertson, Jr., the Deputy Secretary of Defense was titled "Use of the JUPITER Re-entry Test Vehicle as a Satellite" and dated 5 July 1956. It received the lower classification of "Confidential." It sheds a great deal of light on the issue of why the United States chose to wait until the end of 1957 before making a satellite launch attempt when it was within its ability to attempt such a feat much earlier. Murphree stated that he had looked into the matter of using a Jupiter re-entry test vehicle for possibly launching a satellite into orbit. He stated that the January 1957 test could be adapted to this purpose with little effort and no impact on the programme and said that an attempt could be made in September 1956, although this would affect the Jupiter programme.

Murphree further noted that proposals for using the Jupiter were not new and that the original Redstone satellite and re-entry test vehicle proposals resulted from a common study (made by Wernher von Braun) which argued that the same vehicle could be used for both. Murphree also stated that the first two tests of the Jupiter were essentially propulsion system tests and could accomplish much of their goals for that programme even if used for satellite launch attempts. Murphree continued,

"There is, however, room for *serious doubt that two isolated flight attempts would result in achieving a successful satellite*, and the dates of such flights would be prior to the Geophysical Year for which a satellite capability is specifically required, and prior to the time when tracking instrumentation will be available."

Murphree then stated that these facts were taken into consideration at the time that the Office of the Secretary of Defense reviewed the satellite program and decided to assign the mission to the Viking group. He stated,

"That decision was based largely on a conviction that the VANGUARD proposal offered the greater promise for success. The history of increasing demands for funds for this program confirms the conviction that this is not a simple matter. *I know of no new evidence available to warrant a change in that decision at this time.*"

The rest of the memorandum is extremely interesting and is reprinted below in full:

"While it is true that the VANGUARD group does not expect to make its first satellite attempt before August 1957, whereas a satellite attempt could be made by the Army Ballistic Missile Agency as early as January 1957, little would be gained by making such an early satellite attempt as an isolated action with no follow-up program. In the case of VANGUARD, the first flight will be followed up by five additional satellite attempts in the ensuing year. It would be impossible for the ABMA group to make any satellite attempt that has a reasonable chance of success without diversion of the efforts of their top-flight scientific personnel from the main course of the JUPITER program, and to some extent, diversion of missiles from the early phase of the re-entry test program. There would also be a problem of additional funding not now provided.

For these reasons, I believe that to attempt a satellite flight with the JUPITER re-entry test vehicle without a preliminary program assuring a very strong probability of its success would most surely flirt with failure. Such probability could only be achieved through the application of a considerable scientific effort at ABMA. The obvious interference with the progress of the JUPITER program would certainly present a strong argument against such diversion of scientific effort.

On discussing the possible use of the JUPITER re-entry test vehicle to launch a satellite with Dr. Furnas, he pointed out certain objections to such a procedure. He felt there would be a serious morale effect on the VANGUARD group to whom the satellite test has been assigned. Dr. Furnas also pointed out that a satellite effort, using the JUPITER re-entry test vehicle may have the effect of disrupting our relations with the non-military scientific community and international elements of the IGY group.

I don't know if I have a clear picture of the reasons for your interest in the possibility of using the JUPITER re-entry test vehicle for launching the satellite. I think it may be helpful if Dr. Furnas and I discuss this matter with you, and I'm trying to arrange for a date to do this on Monday."

The Third Memorandum

The meeting took place on 9 July 1956, being mentioned in a brief, one-page memorandum from C.C. Furnas to Deputy Secretary of Defense Robertson, dated 10 July 1956 and stamped 'Secret'.

Furnas used this memorandum as a cover letter to forward the previous report to him by Homer Stewart's Advisory Group on Special Capabilities. He concluded by saying,

"I trust that this will serve your purpose in reporting your evaluation of the suggestion that a Redstone vehicle will be used."

At the White House

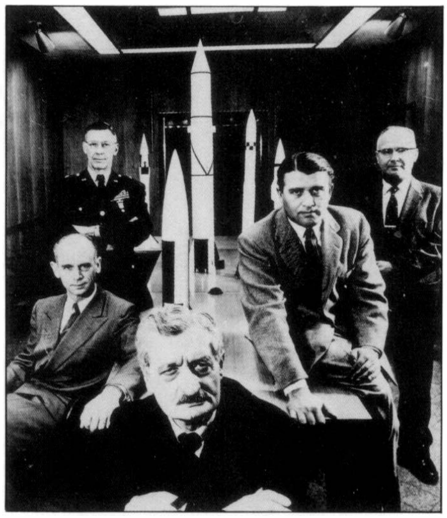
Deputy Secretary of Defense Robertson's special assistant, Charles G. Ellington, forwarded the memos to White House Staff Secretary Andrew Goodpaster. Goodpaster wrote on the bottom of Ellington's cover memo, "Secy. Robertson feels no change should be made - per Mr. Ellington. Reported to President." (Ewald, p. 284)

It is not clear from where the original question of having the Army involved in satellite launches originated. But lurking in the background of most of Eisenhower's early space policy was Donald Quarles. Quarles had started out in 1953 as Assistant Secretary of Defense for R&D, a post he held until becoming Secretary of the Air Force in 1955. He served in that position until 1957, when he took over Robertson's post as Deputy Secretary of Defense. In 1952, Aristid Grosse, a physicist at Temple University and former Manhattan Project scientist, had been asked by President Truman to prepare a report on "the Present Status of the Satellite Problem." The report was not ready before Truman left office and instead presented to Quarles, as head of R&D for the Pentagon. Quarles later became a major advocate of the use of space for military purposes and, as Secretary of the Air Force, may have been the person who influenced Robertson into asking about the feasibility of using the Jupiter booster.

US Program Held Back?

Several historians writing about this period have claimed that Eisenhower and Quarles deliberately held back the U.S. satellite programme in order to allow the Soviets to launch first. Steven Ambrose in his biography of Eisenhower, Walter MacDougall in his Pulitzer Prize winning . . .*the Heavens and the Earth* and Air Force historian Cargill Hall in several essays on the subject have all claimed that Eisenhower wanted to allow the Soviets to establish the "right of overflight" by satellites over foreign territory. Hall has called the Scientific Satellite Program a "stalking horse" for the military reconnaissance satellite programme. The memos excerpted here seem to refute that case a great deal and, despite extensive effort, the author has not been able to locate a "smoking gun" proving this argument.

However, although it is not clear that the US programme was held back for any other reason than to prevent it from interfering with the ballistic missile program, new information has emerged indicating that the CIA did indeed take an active interest in the Scientific Satellite Program, an issue that needs to be addressed in a future article.



The ABMA (Army Ballistic Missile Agency) effort was directed by Brig. Gen. Holger Toftoy, upper left, who had helped to recruit a team of German missile engineers. Shown here in 1954 are Dr Ernst Stuhlinger, front left; Prof. Hermann Oberth, foreground; Wernher von Braun; and Dr Robert Lusser, extreme right.

On 8 November 1957, after the launch of Sputnik 2, the Pentagon authorised the Army to launch an Earth Satellite. The Army took its chance and moved in to snatch the glory of launching America's first satellite on 31 January 1958.

Acknowledgements

These records were obtained by the author as part of the ongoing Documentary History of the US Civilian Space Program at the Space Policy Institute, George Washington University. These and other documents will be contained in the forthcoming book: *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program.* The author wishes to extend his thanks to Linda K. Smith and the Mandatory Review Staff of the Dwight D. Eisenhower Library.

References

1. Homer J. Stewart, Chairman, Advisory Group on Special Capabilities, Memorandum for the Assistant Secretary of Defense (R&D), "VANGUARD and REDSTONE," June 22, 1956, White House Office, Office of the Staff Secretary: Records, 1952-1961, Box 6, "Missiles and Satellites," Dwight D. Eisenhower Library.
2. E.V. Murphree, Special Assistant for Guided Missiles, Memorandum for Deputy Secretary of Defense, "Use of the JUPITER Re-entry Test Vehicle as a Satellite," July 5, 1956, White House Office, Office of the Staff Secretary: Records, 1952-1961, Box 6, "Missiles and Satellites," Dwight D. Eisenhower Library.
3. C.C. Furnas, Assistant Secretary of Defense for Research and Development, Memorandum for Deputy Secretary of Defense, July 10, 1956, White House Office, Office of the Staff Secretary: Records, 1952-1961, Box 6, "Missiles and Satellites," Dwight D. Eisenhower Library.

The specifically configured F4D-1 "Skyray" (tail number 745) used for the NOTSNIK airdrops, shown here in 1960 with the first Caleb follow-on test vehicle.
COMMANDER WILLIAM W. WEST (US NAVY ret)

BY JOEL W. POWELL
Space Information Canada

NOTS Air-Launched Satellites

Three decades before there was a Pegasus rocket, the first effort to orbit a satellite from an aerial platform occurred over the Pacific Ocean 100 miles west of Los Angeles. The missile design team of the Naval Ordnance Test Station (NOTS) at China Lake in California made six attempts to air-launch a satellite in the summer of 1958. Information on this secret programme has now become available so that the full story of the NOTS launches can finally be told.

A 45-foot Douglas F4D-1 "Skyray" carrier-based jet (Navy BuAer serial number 130745) was chosen to carry the NOTS rocket. With a fin span of 5.4 feet, the rocket would barely fit within the Skyray's ground clearance. Shaped like a manta ray, the distinctive "all-wing" fighter was a specially stripped-down version utilised for speed trials at the base (top speed on afterburner was Mach 1.05). Navy Commander William W. West, whose wartime service included flying Hellcat fighters from the USS Enterprise, was selected to pilot the launch aircraft. Commander West logged countless hours in the air to perfect the precision "bomb-toss" launch manoeuvre.

The 2,100-pound NOTS rocket was mounted under the left wing of the aircraft on a standard Aero 7A bomb rack. To counterbalance the offset load, a large fuel tank was carried under the right wing. Though officially known as "Project Pilot", the rocket quickly acquired the nickname "NOTSNIK" at the station.

The flight profile was as follows. After departing the NOTS airfield at Inyokern, the Skyray was to proceed at a cruising altitude of 35,000 feet to the Navy test range at Point Mugu, situated on the California coast just north of Los Angeles. After flying south to the drop zone over the Santa Barbara Channel, the pilot would initiate a 2-g pull-up manoeuvre at Mach 0.9 and enter a 58 degree climb. Release of the rocket occurred automatically at 41,000 feet, followed by ignition of the first two HOTROC motors three seconds later.

Each HOTROC pair were scheduled to burn for 4.86 seconds with a gap of 12 seconds between them. The 35 second fourth-stage burn (after a 100 second coasting period) would be followed by a brief 5.7 second firing of the fifth stage. A tiny 1.25 pound sixth-stage rocket motor was built into the eight-inch payload to inject it into orbit at an elapsed time of 53 minutes. The one-second burn would add an additional 1,700 feet per second to the satellite's velocity.

In reality, things did not go exactly as planned for the NOTS rocket team. An indication of trouble came during two ground test flights of the HOTROC motors. Mock-ups of the vehicle with two live HOTROCs were launched from the G-2 test range at China Lake. The first, on Independence Day, ended with an explosion after only one second aloft. It was later determined that the explosion was due to a cracked propellant grain. The second test vehicle never made it into the air. Eight seconds before the end of the countdown, the stationary HOTROC motors blew up, the victim of an electrical system glitch.

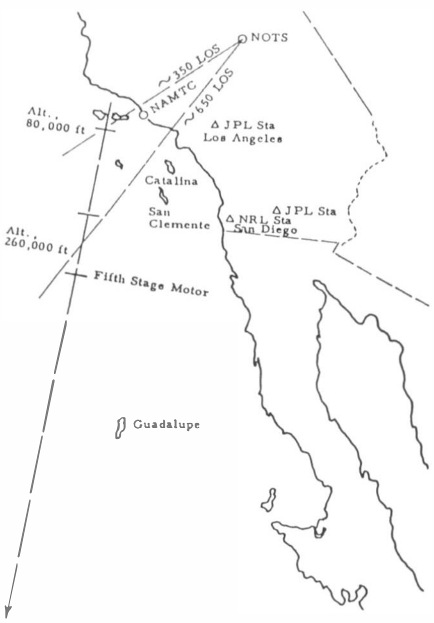
NOTS managers were under pressure to launch their satellites by August 8 to meet a deadline imposed by the Argus series of high-altitude nuclear tests. Three of the NOTS satellites were instrumented to record radiation from the Argus blasts. As it turned out, the Argus tests were not conducted until after the NOTSNIK flights.

On 25 July 1958, Commander West lifted off from Inyokern with the first NOTS vehicle tucked under the Skyray's wing. He headed for the drop zone over the Santa Barbara Channel located at coordinates of 34 degrees North and 120 degrees West.

A burst of smoke and flame obscured the rocket at ignition and prevented Commander West and the chase pilot from tracking it further. Believing that the shot had failed, the two aircraft returned to Point Mugu for re-fuelling. When the tracking stations reported hearing strange signals, hopes for success were briefly rekindled. Unfortunately, further evidence was not forthcoming due to the primitive state of contemporary tracking facilities and an inadequate telemetry system on the vehicle.

Eighteen days later, NOTS tried again. The HOTROC motors blew up at ignition, causing Commander West

Trajectory map of the NOTS air-launched satellite attempts of 1958.



This article is an edited version of the column 'Launch vehicles and their role in the history of spaceflight' that appeared in the Spring 1994 issue of QUEST magazine, Grand Rapids, MI, USA.

All drawings, data and the above photograph are courtesy Commander William W. West (US Navy ret.) to whom the author is indebted for providing the NOTS technical memorandum (unclassified) upon which the article is based.

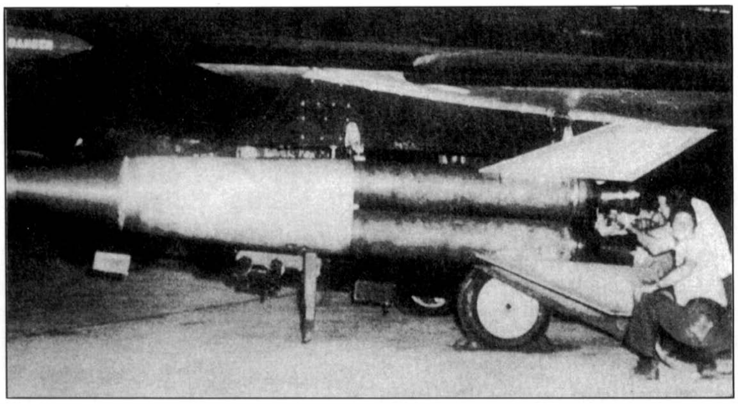
Joel W. Powell is a space flight historian and has been writing about space since 1979. He is author of Space Shuttle Almanac and a frequent visitor to NASA KSC for Shuttle missions.

to enter a spin and nearly lose control of his aircraft. After this narrow escape, two additional ground tests were conducted at NOTS. During these tests, both missiles shed their fins and broke up within three seconds after liftoff. These failures seemed to indicate that the vehicles lacked adequate structural strength to withstand the stresses induced during launch.

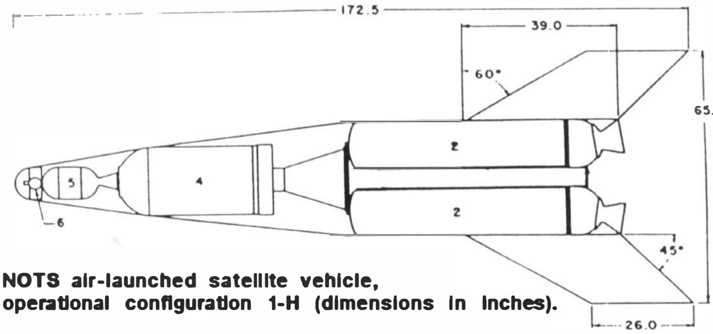
The third attempt on 22 August again raised hopes that NOTSNIK may have achieved orbit. The pilots lost sight of the vehicle after release but the NOTS tracking station at Christchurch, New Zealand reported receiving possible signals from space at the scheduled times of the first and third passes. Privately, the NOTS management did not believe that the satellite had entered orbit. The signals were so faint that they may have been nothing more than a case of wishful thinking on the part of the operating technicians. Unfortunately, this was as close to success as the project ever came.

The three remaining vehicles were expended in rapid-fire order within the timeframe of four days. Two attempts in late August ended with HOTROC motor malfunctions, while the other failed to ignite and plummeted into the Pacific.

In spite of the unfavourable results, development of the air-launch technique continued at NOTS with the improved Caleb vehicle. Caleb was cancelled in 1962, perhaps due to the pressure applied by the Air Force to preserve their monopoly of military space launch services. The aerial concept was not considered again until Pegasus proved its validity once and for all in April 1990.



Live NOTS rocket positioned beneath left wing of Skyray launch aircraft at NOTS airstrip in Inyokern, California.



NOTS air-launched satellite vehicle, operational configuration 1-H (dimensions in inches).

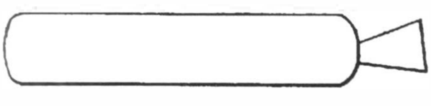
Table: NOTSNIK chronology.

Operation	Date	Result
1st ground test firing	4/7/58	Exploded within 1 second of liftoff
2nd ground test firing	18/7/58	Blew up on launcher at T-8 seconds
Orbital attempt #1	25/7/58	Vehicle performance uncertain
Orbital attempt #2	12/8/58	HOTROC motors blew up at ignition
3rd ground test firing	16/8/58	Broke up after 3.2 seconds
4th ground test firing	17/8/58	Broke up after 3.0 seconds
Orbital attempt #3	22/8/58	Missile disappeared over horizon, performance uncertain
Orbital attempt #4	25/8/58	One HOTROC exploded after 0.75 seconds
Orbital attempt #5	26/8/58	Failed to ignite, fell into sea
Orbital attempt #6	28/8/58	Only one HOTROC ignited, broke up

Solid Propellant Stages

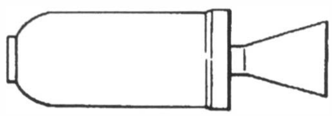
The one ton solid propellant NOTS rocket (which pre-dated the Scout launch vehicle by nearly two years), was just 14.3 feet long and 30 inches in diameter. Due to lack of resources and restrictions on vehicle size and weight, project engineers were forced to improvise on many aspects of the rocket's design. For instance, a thin-walled version of the motor from the ASROC anti-submarine weapon was developed to serve as second and third stages of the vehicle with the aircraft serving as the first stage. Two pairs of these modified HOTROC motors (providing 28,400 pounds of thrust per pair) provided the initial launch thrust after separation.

The X-241 fourth stage, with 2,720 pounds of thrust, was produced by Allegeny Ballistics Laboratory as a backup third stage for the Navy's Vanguard program. NOTS designed and fabricated the fifth and sixth stages at China Lake specifically for the program. Collectively, the five-stage vehicle was capable of injecting 2.3 pounds of payload into orbit with an apogee of 1,500 miles.



HOTROC - 2nd and 3rd stages

length	71 in
diameter	11.65 in
total weight	360 lb
propellant weight	300 lb
operating pressure	900 psi
burning time	4.86 sec
thrust	14,200 lb
specific impulse	230 lb-sec/lb
total impulse	69,000 lb-sec
motor performance index	192



ABL X241 - 4th stage

length	58.2 in
diameter	18.0 in (nom)
total weight	432 lb
propellant weight	376 lb
operating pressure	200 psi
burning time	36 sec
thrust	2720 lb
specific impulse	260.1 lb-sec/lb
total impulse	97,930 lb-sec
motor performance index	225

Extruded - 5th stage

length	18.6 in
diameter	8.0 in
total weight	329 lb
propellant weight	26.9 lb
operating pressure	500 psi
burning time	5.7 sec
thrust	1155 lb
specific impulse	245 lb-sec/lb
total impulse	6590 lb-sec
motor performance index	200

Spherical - 6th stage

length	5.5 in
diameter	3.0 in (nom)
total weight	1.25lb
propellant weight	0.7 lb
operating pressure	1,500 psi
burning time	1.0 sec
thrust	172 lb
specific impulse	245 lb-sec/lb
total impulse	172 lb-sec
motor performance index	138

Charting a Future for Air Launch to Orbit

It has been a slow takeoff for air-launched satellites - from the early NOTS attempts of 1958 (see p.374) to the first Pegasus orbital launch in April 1990. One of the clever features of Orbital Science Corporation's Pegasus launching system is that it cuts costs dramatically by using a second-hand commercial airliner for airlaunch of the winged rocket booster. But could we yet be at the beginning of a long-term evolutionary process? The introduction of new high-tech developments in conjunction with low-tech designs where both prove their cost-effectiveness has much to offer according to *Jaro Franta* who has some ideas on the matter to put forward.

BY JAROSLAV FRANTA
Consultant Engineer
Quebec, Canada

Blimp Launch

Unfortunately, the extensive modifications performed on the former Air Canada Lockheed L1011 Tristar airliner [1] make it useless for other commercial duty, except perhaps parcel post mail delivery. This means that the capital investment sits idle for long periods between launches. Moreover, the airliner's low ground clearance drastically limits any future expansion of the booster vehicle, such as might be required to add air breathing capability in order to achieve increased payload fraction or single-stage-to-orbit and full reusability performance.

Both of these inadeqacies can be eliminated by switching from an airliner to a heavy-lift lighter-than-air craft, ie. a large dirigible or blimp. Orbital booster vehicle launch would then simply be a vertical gravity drop, with airbreathing engine ignition occurring once the freefall acceleration increases air speed to around Mach 1, which would be followed by a pullout from the vertical dive and resumption of a standard Pegasus-type orbital boost trajectory. This would be less risky than a high-speed, 550km/h (300knots) HOTOL type runway sled launch or even a SKYLON type rocket-assisted take-off (RATO)[2], but it would require special ground handling facilities to suspend the fully-fuelled orbital booster from the blimp before launch.

Between launches the blimp could be operated profitably for heavy lift service in any number of industrial activities, ranging from timber transport, to high-voltage powerline pylon installation in remote or inaccessible regions, to highrise office building and offshore oilrig construction, or possibly even long distance cargo transport (with considerably less restrictions on cargo geometry or landing area than an airliner!). Conceivably, it might even be possible to stack the blimps vertically to achieve the extra lift required for the orbital booster, while dividing up the lifting capability over two or three smaller blimps. This would multiply the fleet's commercial viability, while reducing unit cost - with almost no penalty to launch operations, because unlike ground-to-ground transport, no precision aerial manoeuvring is required of the blimp stack after take-off. The blimps would separate at high altitude, seconds prior to booster vehicle drop, and return to the airport individually.

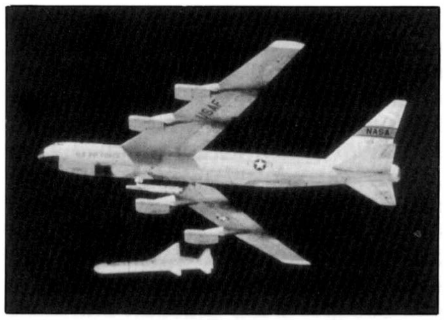
Liquid-Fuel Boost

If a launch abort return to airport capability is desired, then even the rocket propulsion of the booster must be liquid fuelled so that all fuel can be dumped and a single blimp can bring it back safely. For solid rockets the lack of this option for blimp airdrop launches is a serious drawback, but if it is tolerated for ground-launched rockets, it should also be feasible in the former case. Moreover, if the launcher were to be reusable, then there is always the possibility of burning out the solid rocket without going all the way to orbit and then simply performing a normal post-reentry landing.

Liquid fuel is also desirable from the point of view of airframe design, because it allows far more flexibility in tankage and payload packaging than the solid rocket fuel cyllinders of Pegasus-type rocket planes. A mix of solid and liquid is almost equally flexible, so a combination of air breathing liquid fuelled engines and a solid rocket booster may be contemplated.

High-Tech Aerodynamics

This design flexibility in turn allows one to take advantage of much better lift-to-drag (L/D) ratio performance available with certain types of hypersonic aircraft designs. Computational fluid dynamic studies [3] and wind tunnel validation tests [4,5] of so-called viscous-optimized hypersonic waveriders at off-design Mach numbers have shown excellent L/D performance in the entire range from Mach 2 to Mach 8 and higher, with only gradual degradation in performance at the higher Mach numbers. This is exactly the range of Mach numbers at which Pegasus operates before leaving the atmosphere, but its L/D over this range is nowhere near the 8 to 14 values for the best waveriders. Here we have an amazingly efficient way to deliver a booster rocket to high altitude, which no one seems to be interested in taking advantage of!



NASA's B-52 drop aircraft, which entered service in 1954, has been involved in Pegasus test flights and launches since 1989 until recently replaced by a modified Lockheed Tristar airliner. NASA

The high L/D of waveriders also makes it much easier to design for atmospheric reentry from orbit, because the gentle descent greatly reduces aerodynamic heating. Its like the difference between an amphibious aircraft landing on a lake compared to hitting the water cannonball-style! That is because even at Mach 20-or-so, waveriders still have a glide ratio in the range of 4.0.

Making the launcher reusable also has an advantage over Pegasus-type multi-stage rockets in that a monocoque airframe - even one with a single-stage solid rocket motor cylinder installed inside - is much easier to design in a structurally sound way than a series of joined fuselages which must separate in mid-flight, and is of course also more weight efficient. In the case of a waverider-type reusable launcher, readers must beware of reports in which designers have decided to trade much of the L/D advantage for a greatly increased volume-to-surface ratio of the vehicle. This is done in the case of aeroshells for interplanetary spacecraft intended for exploiting the potential of so-called aero-gravity assist (or AGA) manoeuvres to achieve large Δv, because this requires extremely robust construction to withstand the 25 "gee" centrifugal accelerations at speeds in excess of Mach 80.0 [6,7]. No such requirement exists for orbital launchers, so designs closer to the optimum L/D are preferred.

Propulsion Problem

Despite all the advantages of airlaunch [8], propulsion still remains a serious problem for achieving (airlaunched) SSTO performance with a reasonable payload size, especially for aerospace craft of Pegasus or only slightly larger scale. A pure rocket needs too much fuel, reducing payload size to insignificance. For

HOTOL- or SKYLON-type air combusting rocket engines Alan Bond stated correctly that small vehicles using this type of engine are uncompetitive due largely to high development costs of such complex engine systems [9]. There is nothing simpler than solid rockets and lighter than ramjets however, and the vertical drop Mach 1 ignition launch sequence is ideal for their use in small reusable vehicles.

In keeping with OSC's philosophy of "not inventing anything we don't have to" [10], the reusable waverider aerospace plane could make use of Marquardt's RJ43-MA11 ramjet engines. Each of a set of 17 existing D-21 Mach 3.3 reconnaissance drones has one of these engines. They were flown in the late 1960s and early 70s, airlaunched from SR-71 and B-52 turbojet carrier aircraft, and are now being distributed to museums and to NASA following years of storage at an Arizona U.S. Air Force Base [11]. Removing the engines could hardly lessen the public's enjoyment of the displays.

Four of the large engines would probably be required to loft each waverider and a 15-tonne internally mounted solid fuel booster rocket to the latter's ignition altitude of 30 to 36 kilometers and Mach 3 to 4. This is three times higher than the Pegasus airlaunch/ignition altitude, and in fact corresponds to first-stage burnout altitude. In effect, about two thirds of Pegasus' length and three quarters of its weight is replaced by a bunch of hollow tubes (the ramjets) and some jet fuel. While adding the ramjets increases the launcher's cost and complexity, replacing the multistage solid rocket with a single stage one reduces cost and complexity. The ten times higher specific impulse of airbreathing ramjet engines relative to rockets makes the tradeoff worthwhile. Also, the recent destruction of the first airlaunched Pegasus XL booster and its $15 million U.S. Air Force STEP 1 spacecraft payload, because of a failure of the second stage rocket to ignite [12], undoubtedly left OSC's engineers wishing their booster only had a single stage!

Recovery

Small rockets for manoeuvring in orbit and for return to the atmosphere would also be required, but after the hypersonic glide and eventual slowing and descent to low altitude, recovery of the launcher could either be by way of parachute and ocean splashdown - just like the giant reusable Space Shuttle SRBs - or by way of an X-15 style desert runway landing on a pair of skis and a steerable front wheel. The latter type of recovery is much neater and more convenient, but complicates the waverider airframe structure. A supersonic air intake scoop would be the only other penetration into the base of the fuselage (the externally protruding part of the air compressing duct and ramp would probably have to be jettisoned after ramjet shutoff to get rid of the parasitic drag, if no convenient solution is found to retract it inside).

In Summary

The important thing is to use "high-tech" aerodynamic design and composite airframe and solid rocket motor shell construction - which costs relatively little - and "low-tech," low cost and low maintenance propulsion.

An artist's impression of a Pegasus launch.

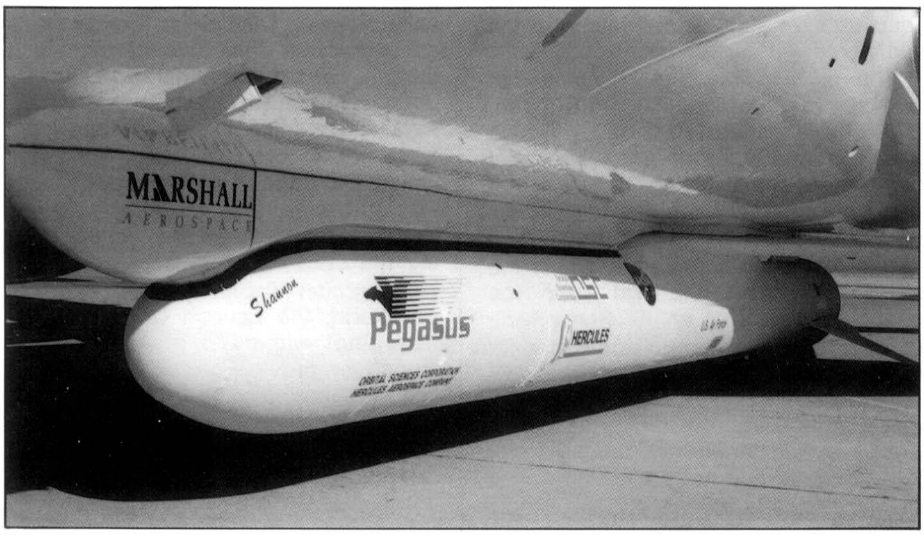
References

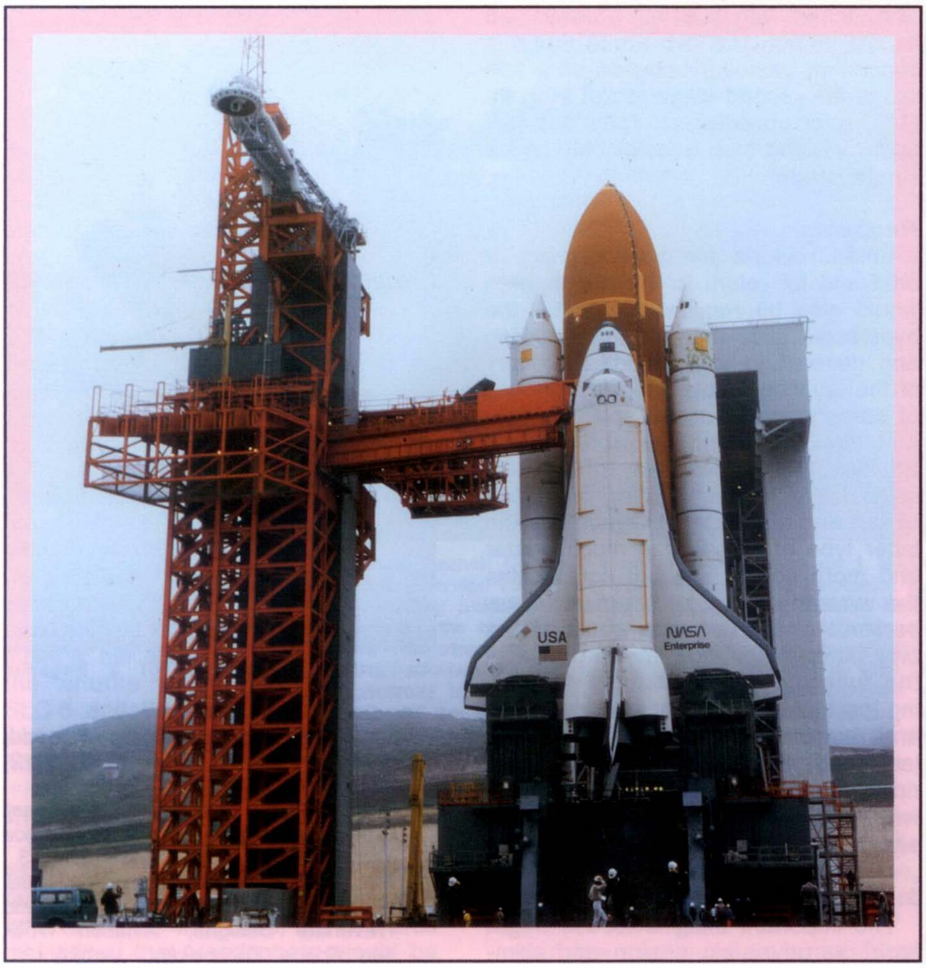
1. Curtis Peebles, "Pegasus Launch Aircraft," ***Spaceflight***, **36**, No.2, February 1994, pp.45-46.
2. Alan Bond, "SKYLON: A Key Element of a Future Space Transportation System," ***Spaceflight***, **35**, No.5, May 1993, pp.162-166.
3. X. He and M.L. Rasmussen, "Computational Analysis of Off-Design Waveriders," *AIAA Journal of Aircraft*, **31**, No.2, March-April 1994, pp.345-353.
4. S.W. Kandebo, "Waverider Tests Boost Credibility," *Aviation Week and Space Technology*, Sept. 13 1993, pp.62-63.
5. E.H. Phillips, "NASA Completes Initial Wind Tunnel Tests with Hypersonic Waverider Designs," *Aviation Week and Space Technology*, January 21, 1991, pp.54-55.
6. D.J. Tincher and D.W. Burnett, "Hypersonic Waverider Test Vehicle: A Logical Next Step," *AIAA Journal of Spacecraft and Rockets*, **31**, No.3, May-June 1994, pp.392-399.
7. J.E. Randolph and A.D. McRonald, "Hypersonic Maneuvering for Augmenting Planetary Gravity Assist," and "Solar System 'Fast Mission' Trajectories Using Aerogravity Assist," *AIAA Journal of Spacecraft and Rockets*, **29**, No.2, March-April 1992, pp.216-232.
8. David I. Wade, "Air-Launched Boosters," ***Spaceflight***, **35**, No.11, November 1993, pp.362-365.
9. Alan Bond, "The SKYLON Spaceplane - Technology and Economics," Response to Readers' Letters, ***Spaceflight*** **35**, No.7, July 1993, pp.240-242.
10. John Childs, "Spacesaver," *Aviation Week and Space Technology* market supplement (Sept.3, 1990, pp.S1-S10).
11. "NASA Acquires D-21 for Research," *Aviation Week and Space Technology* News Breaks (June 20, 1994, p.16).
12. Smith, Bruce A.: "OSC Seeks Cause of Pegasus XL Failure," *Aviation Week and Space Technology* Headline News (July 4, 1994, p.30).

About the Author

Mr Franta is a mechanical engineer currently working on a James Bay hydroelectric project. He has written numerous articles on nuclear and aerospace issues, in both local and international periodicals. His greatest interest is that of issues involving the overlap of nuclear and aerospace technologies.

A close-up view of the Pegasus XL booster beneath the Lockheed L1011 airliner purchased from Air Canada. The XL booster is significantly longer and heavier than the original Pegasus. Clearance between XL and the ground is minimal. (See *Spaceflight*, February 1994, p.45).
CURTIS PEEBLES





The "non-flying" Space Shuttle *Enterprise* is poised on the launch mount at SLC-6 in early 1985. The Orbiter was mated with a pair of inert Solid Rocket Boosters and a flight-qualified External Tank for facility verification testing. The Mobile Service Tower, seen in the background, has been retracted to its ready-for-launch position. This is the only Space Shuttle ever processed at Vandenberg AFB. FROM THE COLLECTION OF HARRY BERNARD

VANDENBERG

Space Shuttle Launch and Landing Site

Part 2 - Abandoned in Place

BY ROGER G. GUILLEMETTE
Rhode Island, USA

First Flight Preparations

In February 1985, an all-military crew was announced for the first manned polar-orbit space flight and the first Shuttle mission to be launched from SLC-6. It would be piloted by USAF Lt. Col. Guy S. Gardner, and included mission specialists USAF Maj. Jerry L. Ross, USAF Col. R. Michael Mullane and Navy Cdr. Dale Gardner. Later, two payload specialists would be added to the roster, USAF Maj. John B. Watterson and, Undersecretary of the Air Force Edward "Pete" Aldridge. Aldridge's assignment as a "payload specialist" on a very complex mission had few supporters within NASA. A high-ranking Shuttle program official (who requested anonymity) was very blunt in his remarks to the author, "There was absolutely no mission function that required the presence of the Undersecretary of the Air Force on that flight. It was pure public relations". However, the civilian space agency was not in any position to be casting stones; after all, they had already flown a Saudi prince and a Senator and were about to fly a Congressman and a school teacher. This flight would belong to the Air Force.

The mission would be commanded by veteran Astronaut Robert Crippen, pilot of the first Space Shuttle mission and commander of three subsequent flights and, a US Navy Captain. Crippen's assignment was loudly questioned by some in the Air Force and raised many more eyebrows within the service. After all, the first Air Force space mission from an Air Force facility built with Air Force dollars was to be commanded by a Navy Captain?

NASA refused to budge. The agency owned the Orbiter, not the Air Force, and they considered the first Vandenberg Shuttle mission to be the most demanding and potentially hazardous mission ever flown. A launch from an untried facility with a brand-new ascent profile and abort sites, coupled with the unknowns of reentry over the poles, required a highly-skilled commander at the helm. NASA Johnson Space Center Director Gerald Griffin considered Crippen to be his most experienced commander and decided that this highly challenging flight demanded the best. The rationale for that decision could not be questioned.

For Part 1 - Construction of Shuttle Launch Facilities, see the October issue, p.354.

Perception and Reality

In early 1985, the Public Affairs Office at Vandenberg announced that "construction of the launch facility is finished, ground support equipment has been installed, and facility verification ... is complete. All launch systems will be checked out and ready to support launch activities this year."

On 15 October 1985, President Ronald Reagan proclaimed "Today, the country takes another giant leap in the already very successful space shuttle program by the completion of the Vandenberg Space Shuttle Launch and Landing Complex."

In November 1985, Air Force Magazine declared that "on March 20, 1986, Orbiter 103 known as Discovery will deliver a uniquely important national security payload into low earth orbit from SLC-6...The Pentagon will fly at least one-third of all Shuttle flights over the next ten years." [3].

None of those glowing statements proved to be true. No Space Shuttle has ever been launched from Vandenberg. No operational Orbiter has ever been stacked at SLC-6 or processed in its facilities. After construction projects spanning over twenty years and total expenditures approaching $8,000,000,000, the facility has been "abandoned in place."

Problems and Pitfalls

Despite USAF proclamations to the contrary, SLC-6 was (and still is) critically flawed. Ultimately, the program got no closer than five months to a launch capable configuration.

Four major problems thwarted efforts to complete the facility and have never been resolved. Hydrogen gas would be trapped inside the exhaust ducts; the launch mount holddown posts might damage the Shuttle during the stresses of launch; welds and plumbing on the launch pad are suspect; and, the Launch Control Center might not withstand the stresses of launch or provide protection from the insidious invasion of toxic gases.

Hydrogen entrapment within the SSME exhaust duct is potentially catastrophic. Detonation of gaseous hydrogen within the duct could destroy

both the launch pad and the Space Shuttle. The solution considered most feasible at the time of deactivation would involve injecting super-heated steam into the exhaust duct during SSME ignition. This method would have cost an estimated $36 million, although some estimates place the costs as high as $1,000,000,000 and two years to complete.

Computer simulations have indicated that the holddown posts of the Shuttle Launch Mount might damage the Space Shuttle from launch generated stresses. During a normal Shuttle launch sequence, the Shuttle is "held down" on the launch mount prior to SRB ignition while the SSMEs come up to full power. The thrust generated by the SSMEs causes the Orbiter to strain against the launch mount, a phenomena known as "twang." The SLC-6 launch mount was found to be too stiff and did not flex under the strain of the SSME thrust. Although modified with springs to reduce the stiffness, special testing designed to validate the modifications proved inconclusive.

Welds and plumbing problems plagued the facility from early in its construction until the time it was mothballed. A 1984 NBC News broadcast reported that an unidentified USAF inspector called SLC-6 "an accident waiting to happen" and predicted that the chances were one-in-five that the Shuttle would explode upon launch.

Oxygen storage area valves were found to be contaminated with foreign matter, and an Air Force investigation concluded that defective welding "had gone undetected for over a year and that there was practically no quality control." USAF Colonel Walter Yeager, SLC-6 construction project manager, told NBC News that "welding stainless steel is a difficult job and that it was probably done in haste to get the job done and in a very adverse environment." [4]. The 8,000 welds on the launch pad were X-rayed again to verify that all defects had been identified and fixed.

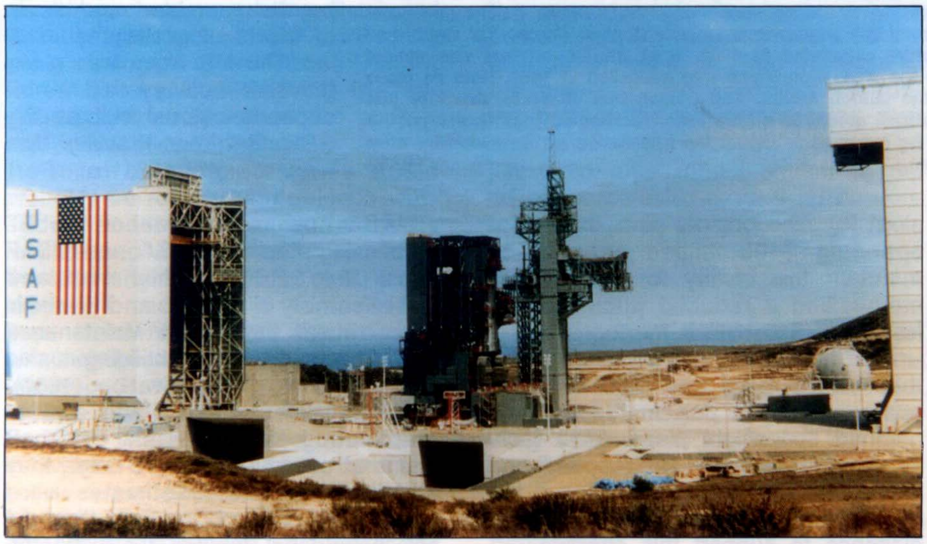
The long-term maintainability of ground support valves is questionable. Many of the primary valves used in the cryogenic and hypergolic support systems were original equipment from the MOL program that had been abandoned almost two decades earlier and their reliablity remains highly suspect.

The close proximity of the Launch Control Center to the launch pad inevitably caused concerns about its capacity to withstand the tremendous forces of a Space Shuttle launch. Folklore and rumours abound about unnamed console operators who reportedly threatened to "call in sick" for the first SLC-6 launch, fearing for their lives.

The bioenvironmental integrity of the LCC is a genuine concern. Studies have demonstrated that the LCC is located within the zone of the heaviest fallout of contaminants produced by liftoff. The breathing air for the LCC is drawn from ventilation shafts only 425 metres from the launch mount. Concentrations of Hydrogen Chloride (HCl) within the LCC would far exceed the levels considered hazardous to human health and in sufficient quantities to corrode sensitive computer components.

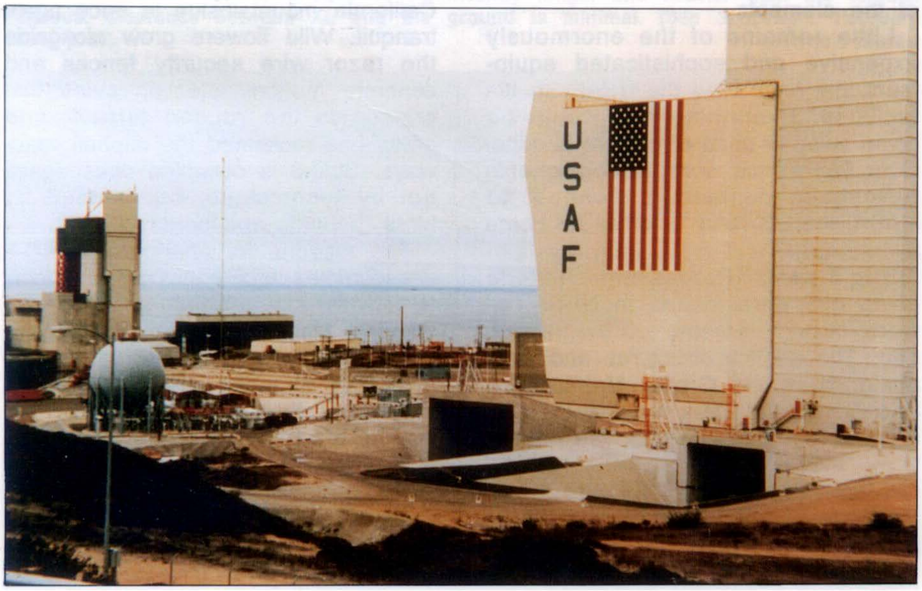
Lt. General Forrest McCartney, USAF (Retired), former director of the Kennedy Space Center and commander of USAF Space Division from 1983 to 1986, has heard those stories and emphatically dispels them. "I had my place all picked out for the launch operations. I didn't have any concerns nor did I encounter anyone else that had any significant concerns who was

The official crest of the Vandenberg Launch and Landing Site.



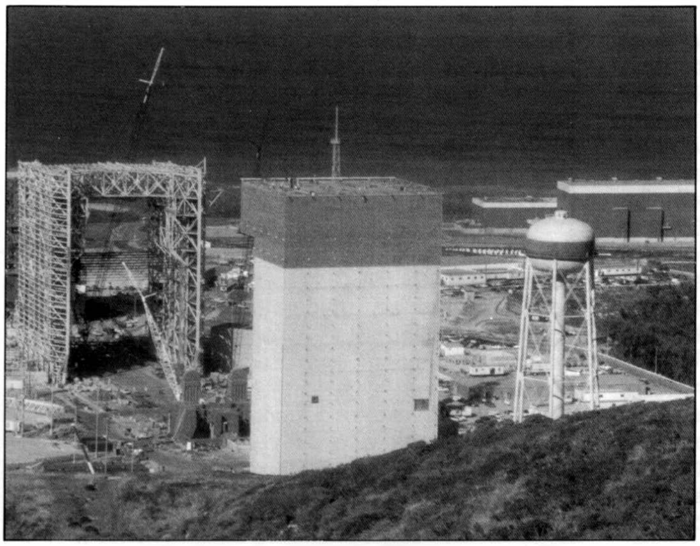
SLC-6 after deactivation. Both the open-doored Shuttle Assembly Building (left) and Mobile Service Tower (right) have been retracted from the launch mount in the parked-for-launch position. The mobile Payload Changeout Room is positioned at the launch mount (centre). The sphere adjacent to the MST is a liquid hydrogen storage tank. The huge exhaust ducts are visible. JIM BANKE

A panoramic view of SLC-6 after deactivation. The Shuttle Assembly Building is mated with the Mobile Service Tower, covering the launch mount. The Payload Preparation Facility (without the mobile Payload Changeout Room) is seen in the background. TODD HALVORSON



knowledgeable within the program. Lots of folklore, lots of accusations, but show me (the evidence) ... The LCC would have been exposed to a catastrophic over-the pad problem, but the probabilities were such that the safety people were comfortable. I had no problem with it, but there was a lot of folklore floating around."

Mission Commander Robert Crippen (current Director of the Kennedy Space Center) also downplayed the risks of the first Vandenberg mission. Responding in 1994 to a question posed by the Author, Captain Crippen said, "I didn't consider it as risky as STS-1 because we had proven the shuttle's capability to fly. I was very confident in our ability to execute the shuttle mission from SLC-6 and I'm disappointed we never had the opportunity".



Space Launch Complex 6 under construction on 1 March 1984. The Mobile Service Tower is in the foreground, the framework for the Shuttle Assembly Building is taking shape and the Launch Mount is visible between the two. The windowless Launch Control Center (far right) was the first structure completed in 1981, work on the original was almost finished when the MOL programme was cancelled in 1969. Note its close proximity to the launch mount. The box-shaped concrete structure just "above" the launch mount is a MOL relic. Nicknamed the "flower pot", a corner had to be removed to permit the installation of the slide-wire crew escape system. **NASA**

Aftermath

For a time after the Challenger disaster, the USAF continued to assert that SLC-6 was only in temporary hiatus. As late as May 1986, the Air Force maintained that Vandenberg would be ready for a Shuttle launch by the time of the "return to flight" scheduled for 1988.

"We're still proceeding as if the launch will be in 1988", contended USAF spokesman Captain Rick Sanford [5]. He noted that work on the residual hydrogen problem was slated for July, Solid Rocket Booster segments would be stacked on the pad in September, and the Shuttle Columbia would be flown to Vandenberg later in the Fall. Furthermore, the crew for the first SLC-6 mission was scheduled to arrive in late 1986 to begin testing, stated Sanford. In June 1986, Secretary of the Air Force Aldridge, the would-be "payload specialist" for the cancelled first SLC-6 Shuttle mission, insisted that the only question was "when is the appropriate time to reactivate Vandenberg, not if we're going to reactivate Vandenberg."

Little over a month later, Aldridge hedged his bets, declaring that sole reliance on the Space Shuttle was a "major mistake for this country" and announcing that SLC-6 would be closed until 1992 and placed in "caretaker status."

Finally, on 2 October 1986, any reasonable hopes of launching Space Shuttles into polar orbit were effectively snuffed out. SLC-6 was placed into mothballs. Aldridge justified the decision to Florida Today, stating "We couldn't justify keeping that facility open for just waiting for a Shuttle mission" [6]. The original plans called for spending $400 million annually to maintain the facility for future use, mothballing it reduced that figure to less than $10 million.

Aldridge continued to emphasize that Vandenberg and SLC-6 would someday play a part in the nation's manned spaceflight plans. "The facility will be there so we can reopen it and reintegrate the Shuttle for flying if the requirement is there." There is scant evidence to support this charade.

The major components of the launch complex, the Mobile Service Tower, Shuttle Assembly Building, and Payload Preparation Facility, stand eerily empty on the magnificent coastline. From all appearances, they are abandoned, standing as monuments to the thousands of millions of dollars spent and slowly falling victim to the ravages of the elements.

Little remains of the enormously expensive and sophisticated equipment that once filled the USAF Shuttle facilities. Everything that could be given away or used elsewhere is gone. Over $85 million worth of components have been donated or "loaned" to NASA, the US Navy or other Air Force agencies.

The Launch Processing Center's computers were loaned to NASA, as were many elements of the launch pad. The service structures and work platforms of the Orbiter Maintenance and Checkout Facility were shipped on a barge to the Kennedy Space Center, where they now form the core of a third Orbiter Processing Facility (see *Spaceflight*, November 1993, p.376).

The Orbiter Lifting Facility was relocated from Vandenberg to the Rockwell international facility in Palmdale, California, where the Orbiters were built and are periodically refurbished. Prior to this, the only means of transporting an Orbiter to/from the Rockwell plant was by towing it through the streets of neighbouring Lancaster (at considerable cost and inconvenience) to nearby Edwards AFB where a permanent mate/demate facility is installed. Locating the portable lifting frame at Palmdale permits Orbiters to be flown in and out directly. In the event of a landing at a contingency site, the Palmdale mate/demate device can still be disassembled and flown to the landing site.

The US Navy was given the SRB recovery ship MV Independence, as well as the SRB Retrieval Facility that was constructed at Port Hueneme.

NASA now makes use of the ET Processing Facility, NASA and USAF share the SRB Refurbishment and Subassembly Facility, and the Air Force retains the Orbiter Maintenance and Checkout Facility building.

At the time of deactivation (1986), USAF officials estimated the cost of reactivating SLC-6 from mothball status at over $675 million. Later, they admitted that those estimates were understated, in part, because they did not include full funding for fixing the launch complex's deficiencies, including the hydrogen entrapment problem. Conservatively, reactivation of SLC-6 would take over six years and cost far in excess of $1,000,000,000.

Postscript

Instead of reeling under the incredible power of Shuttle launches, the California mountainside is once again tranquil. Wild flowers grow alongside the razor wire security fences and concrete motion detection strips that crisscross the rugged terrain, and grass has reclaimed the asphalt roadways. SLC-6 is occupied once again, not by technicians, but instead by birds, bobcats and herds of deer.

The reasons for abandoning SLC-6 are complex and equivocal. Probably the best explanation comes from General McCartney himself, in a recent interview with the author.

"It (SLC-6) really wasn't mothballed; they just walked away from it. I think it was for two reasons: one was emotionalism, because the Air Force desperately wanted to retain Expendable Launch Vehicles ... the other was that NASA was in such total disarray (after *Challenger*)... The nation was in such

a shock. I'd say that the need went away and the emotion of NASA and the Air Force was such that they just walked away from it. Was it good or bad? In retrospect, I'd say that it was probably OK."

General McCartney firmly believes that a Vandenberg launch capability could have been attained by late summer 1986, and the evidence strongly indicates that it would have been technologically feasible, although costly. However, the Challenger disaster and its aftermath forever changed the nation's attitude. In the end, the national resolve for polar manned spaceflight no longer existed.

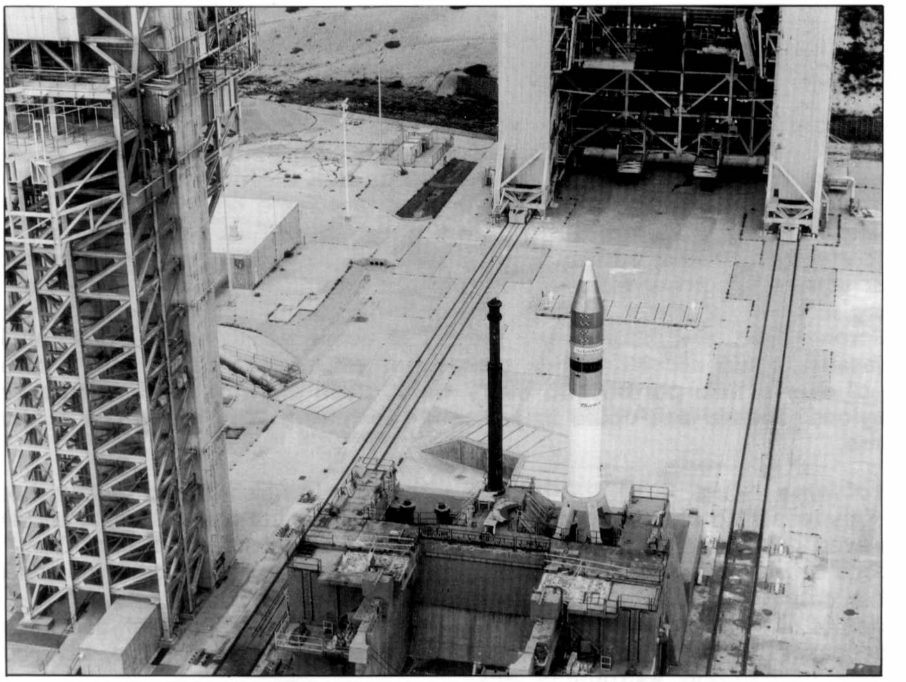
The intense scrutiny of the entire Space Shuttle program after Challenger also served to divert attention away from the unresolved problems at SLC-6. It provided a convenient excuse for the Air Force to cut its losses and quietly close down its multi-billion dollar unfinished launch complex without attracting too much attention. Space Launch Complex Six had been delegated to a mere footnote in the annals of space exploration by the very individuals who promoted and funded it, the political and military leaders of the United States.

Update

Almost thirty years after the first concrete was poured, a rocket may finally be launched into space from SLC-6. Not a Space Shuttle or a mighty Titan, but instead, the inaugural flight of a tiny commercial booster, the Lockheed Launch Vehicle 1 (LLV-1), carrying a 136 kilogram (300 pound) VITA communications satellite into a near-polar orbit.

Now scheduled for launch in late-December 1994, the 20 metre tall, 61,000 kilogram LLV-1 is Lockheed Missile and Space System's answer to affordable access to space for small satellites. Much too small for the actual Shuttle pad, the LLV-1 will be launched from a special adapter that will fit atop the four posts constructed for one of the Space Shuttle Solid Rocket Boosters and use its exhaust duct. Lockheed is leasing the launch complex from the Air Force.

The irony of launching a 136 kilogram satellite frcm a facility built to accommodate mammoth launch vehicles capable of lifting 29,000 kilograms into orbit has not been lost on some in the industry. As one noted space journalist has wisecracked, "It's like renting Heathrow or O'Hare airport to fly your son's radio-controlled model airplane."



Lockheed Vehicle on Shuttle Pad

The scene is now set for the first lift-off from the Vandenberg Shuttle launch site - but not of a Space Shuttle as originally intended. The inaugural flight of Lockheed LLV-1 is scheduled for late December 1994 when it is due to lift-off from a special adapter fitted to the launch pad. The story of how plans for shuttle launches from Vandenberg came to be abandoned after elaborate preparations begins on p.378. ROGER G. GUILLEMETTE

Above: **The "Pathfinder" model of the first Lockheed Launch Vehicle (LLV-1) stands on the Space Shuttle launch mount at SLC-6 in July 1994. The inaugural LLV-1 launch is scheduled for the end of 1994. This will also be the first launch ever attempted from the nearly 30 year-old launch complex.**

The LLV-1 sits atop a specially-constructed adapter that fits over the four mounting posts of the southern Shuttle Solid Rocket Booster mount. The northern SRB mount, at left, has not been modified.

The Mobile Service Tower can be seen in the background, retracted on its rail system to the "ready for launch" position. The Shuttle Access Tower, seen in the left foreground, provides a convenient yardstick to guage the LLV-1's dimensions, Lilliputian in contrast to a Space Shuttle.

LOCKHEED MISSILES & SPACE COMPANY, INC

Acknowledgements

This article would not have been possible without the assistance and generosity of many people, some of whom wish to remain anonymous. I wish to thank and express my heartfelt appreciation to the following: Jim Banke, Todd Halvorson and Mark DeCotis of the *Florida Today* newspaper for their friendship, support, and use of their personal photographs and clipping folders; Space historian Michael Myrick for his assistance; Philip Sloss for access to his archives; Harry Bernard of Lompoc for his kindness, SLC-6 photographs and stories; Keith Scala for his expertise; and finally, the members of the Space Forum and Florida Today Forums of CompuServe for their input and encouragement. I am indebted to US Congressman Ronald K. Machtley and his top-notch staff, Christopher Shaban, Christopher Stack and E. John Seggerman. A special thanks is due to Lt. General Forrest McCartney, USAF for his time and cooperation. It was truly an honour to spend time with him.

References

Information for Parts 1 and 2 of this article was compiled from a variety of sources. The following sources were used extensively:

Florida Today newspaper (formerly *Today*), Melbourne, FL, USA; numerous issues, May 30, 1981 to the present.

Aviation Week & Space Technology, McGraw-Hill, Inc., New York, NY, USA; numerous issues, June 30, 1980 to July 28, 1986.

Vandenberg Space Shuttle Operations, US Air Force Fact Sheet, 1985.

Space Shuttle: Issues Associated With the Vandenberg Launch Site, United States General Accounting Office Reports, 31 October 1986.

Space Shuttle: The Future of the Vandenberg Launch Site Needs to Be Determined, United States General Accounting Office Report, August 1988.

Alonis, Jay J., Major USAF, *Vandenberg Launch and Landing Site: Post Challenger ... Is The Dream Alive?*, Student Report 88-0095, Air Command and Staff College, Maxwell AFB, Alabama, April 1988.

McCartney, Forrest, Lt. General, USAF (Ret.), Interview, 5 February 1994.

Crippen, Robert, Captain, USN (Ret), *Florida Today Forum* On-line conference, CompuServe Information Service: 16 February 1994.

Specific references include the following:

1. *A Second Launch Site for the Shuttle? An Analysis of Needs for the Nation's Space Program;* United States General Accounting Office; 4 August 1978.
2. Toufexis, Anastasia, "New Pad for the Space Shuttle", *Time* Magazine; 5 March 1984.
3. SLC-6 article, *Air Force* Magazine; November 1985.
4. National Broadcastinng Company, *NBC Nightly News*; 20 August 1984.
5. Larimer, Timothy, "Lompoc Still Dreams of Popularity", *San Jose Mercury News*, San Jose, California, USA; 22 May 1986.
6. Halvorson, Todd, "Military Puts West Coast's 'Slick 6' Shuttle Launch Pad In Mothballs", *Floirda Today*, 29 Nov 1988.

–Propulsion Technology

Solar Sails and Kites

Part 1 - Problems, Limitations and Prospects

Second only to the rocket, the solar sail is the oldest and best-known alternative method of space propulsion. The physics behind the concept is easy to understand: photons carry momentum as well as energy, and so electromagnetic radiation, including sunlight, exerts a force on any surface it illuminates. The pressure of sunlight in the vicinity of Earth is quite small: on a perfectly reflecting surface it is 9 μN/m², or just under one kilogram force per square kilometre. However in space, it should be possible to deploy a very large, light mirror surface. For example aluminised polyester film 2.5 microns thick, weighing just 3 gm/m², is commercially available. Sunlight pressure could accelerate this material at 2.7 mm/sec², imparting a delta-V of over a mile per second every week. Even allowing for structure and payload, such a sail could in principle reach very high speeds in a short time.

BY COLIN JACK
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Problems

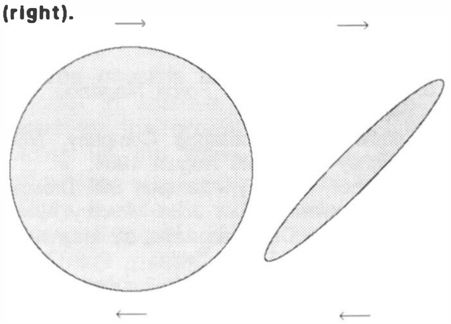
This reasoning has led to an image beloved of science fiction writers and space artists: a spacecraft consisting of a cabin tethered behind square miles of billowing reflective sail, poetic successor to the windjammer, capable of carrying astronauts anywhere in the Solar System or even beyond.

If the solar sail concept is so attractive, why has none been launched? The basic principles are certainly not in dispute. The effects of sunlight pressure have been taken into account in calculating satellite orbits from the earliest days of spaceflight. For example the Echo communications satellites, which were essentially giant balloons of silvered Mylar, were measurably slowed by light pressure as their orbits carried them towards the Sun, and accelerated as they moved away again. Some spacecraft have even been equipped with movable reflecting vanes for attitude control purposes: the solar force on these is too small to affect the craft's course, but sufficient to orient it, to keep it correctly pointed over long periods without wasting valuable manoeuvring fuel.

So why are wasteful and expensive rockets still used to take payloads up from low Earth orbits to geostationary orbit and beyond? Unfortunately, as with so many promising ideas, the application of the principle is not as simple as it seems. In reality, the classical solar sail concept poses hard engineering questions. How to deploy such a large structure from the small canister in which it must be launched? How to control its flight, so it accelerates in the intended direction? Can the sail work in low Earth orbit, the cheapest place to launch it?

Two basic methods of deployment have been proposed. The sail could have a supporting stiff structure of spars. However experience shows that unfolding even a modest rigid structure in space, for example deploying a radio antenna or instrument boom, is a tricky operation. This is always the riskiest part of bringing a satellite up to operational status, and the crippling of the Galileo Jupiter probe (whose main radio dish refuses to unfurl) is only the latest in a long line of failures of this type. Trying to extend a structure hundreds of metres across by similar methods would have a vanishingly small chance of success. Alternatively the sail could be spun, so that centrifugal force spreads it and keeps it taut. The spinning disk illustrated in Figure 1 has come to represent the popular image of solar sailing. Unfortunately, any rotating object prefers to spin about an axis which minimizes its moment of inertia. So a disc-shaped sail would not spin stably about its axis of symmetry, but turn to flip over and over like a tossed pancake, as shown. The only way to remedy this is to fit an active control system which operates at all times during deployment and flight: a demanding engineering proposition.

Figure 1. A classical rotating sail (left) is in fact unstable and would tend to tumble (right).



Limitations

If the deployment problem could be solved, there is still the difficulty of controlling the sail's flight. The direction of the light force vector depends on the sail's orientation relative to the Sun, so its attitude must be controlled. Three possible methods have been studied. The first is to fit small rocket thrusters. This technology is well understood, and used on existing spacecraft. Unfortunately a solar sail, which has a huge moment of inertia due to its size, would burn far too much manoeuvring fuel to be acceptable. A second method is to move ballast masses (such as the payload) around relative to the sail's centre of thrust; the third is to alter the geometry of the sail, for example by opening and closing large flaps of reflective material. These techniques both involve continuously moving parts exposed to vacuum: a major engineering drawback.

Even if the classical sail could be made to work, would it be useful? Crucial to this question is whether it could be operated from low Earth orbit. This is the cheapest place for rockets to reach, and the only region to which low-cost piggyback launch rides are frequently available. Unfortunately, it is a demanding environment for solar sails. First, even a tiny trace of atmospheric drag has a major effect on such a large, light object. Second, tidal forces disrupt the attitude control, tending to pull the sail vertical with respect to the local gravity field. And third, to gain speed efficiently as it turns about the Earth every ninety minutes, the orientation of the sail must alter continuously. This is difficult for any big sail, and almost impossible for a spinning design, which has a gyroscope-like tendency to keep pointing in the same direction.

For these reasons, traditional solar sail designs tend to involve high technical risks, and also need to be launched to a high initial orbit by rocket, leaving relatively little work for the sail itself to do. Launching a payload to a very high Earth orbit actually takes more rocket fuel than accelerating it to escape velocity, and only slightly less than that needed to insert it into a minimum-energy trajectory to Mars or Venus. It is not really surprising that, despite many proposals, no sail has actually been launched yet.

Kite Concepts

I have been studying a different but related concept which I have dubbed the solar kite. There are several fundamental differences between solar kites and the classical solar sail. Kites are much smaller, and are controlled by quasi-passive means, with no moving parts. They are highly manoeuvrable, and can fly from very low Earth orbits: hence they are cheap to launch as well as to build.

The key to the kite concept is the fact that with modern electronics, very tiny payloads can perform useful work. (NASA in particular has been slow to take advantage of this trend: the obsolete computers aboard the Space Shuttle, probably inferior to the one on your desk, are the most notorious example.) It is now possible to build a complete electronic camera on a chip

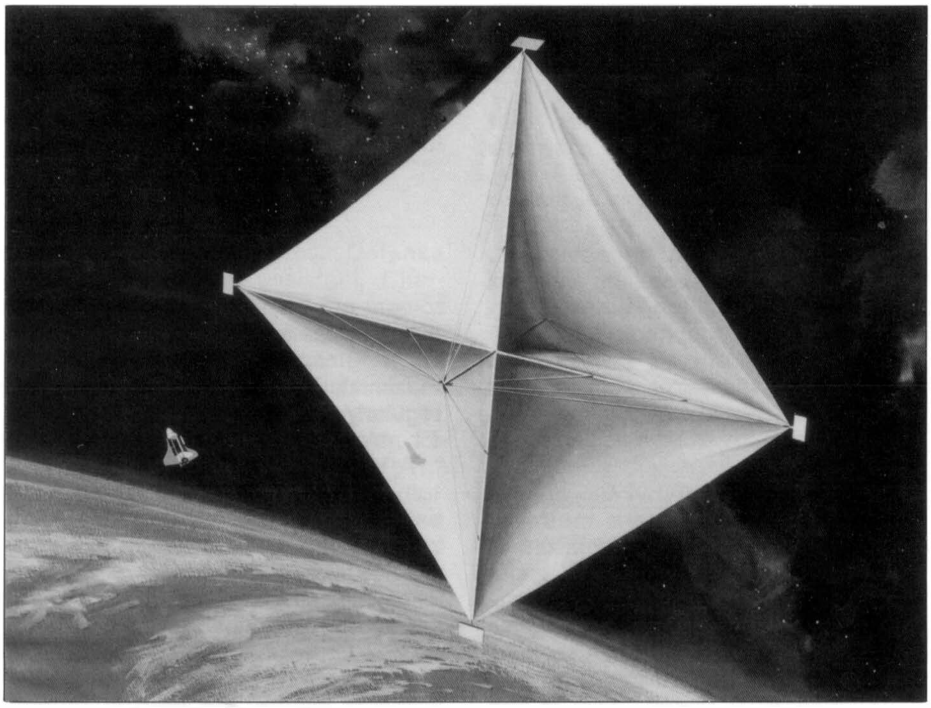
weighing less than a gramme, and other components have undergone equally dramatic reductions. The reason no really tiny spacecraft are launched is that control of the vehicle's motion and attitude requires rocket thrusters, with their associated valves, plumbing and tanks, limiting the minimum practicable size. If this last remnant of mechanical engineering could be dispensed with, very small craft would become capable of sophisticated tasks.

How to control orientation with no moving parts? At first the idea seems almost paradoxical: attitude control requires torque forces, which surely implies some kind of motion. In fact there are several possible ways. To identify them, we must review the fundamental physics underlying solar sailing.

To understand how light exerts a pressure, it is useful to think of the photons as a stream of tiny particles. When these bounce off a surface, they impart momentum to it. In the case of a mirror, tilting the mirror changes the direction of the rebounds, so we can steer a reflecting sail simply by aiming it. But what happens if the light strikes another type of surface, for example one which is black? It seems obvious that the force will be just half that on a mirror, as all the incident photons are caught and retained. However this is only part of the story. The surface does not merely absorb the incident energy, or its temperature would increase indefinitely. In practice, a state of equilibrium is soon reached in which heat is radiated away at the same rate it is absorbed. It is reradiated at infrared rather than visible wavelengths, but the photons still carry a momentum proportional to their energy. If the sail is thin and the same colour on both sides, this reradiation exerts no net thrust. But if the sail is either thick enough to act as a thermal insulator, or silvered on the reverse side, then the reradiation will be almost entirely to sunward, exerting a rocket-like photon thrust. Calculation shows that the total force on such a one-sided black sail is five-sixths that on a perfect reflector.

The result is of particular interest because, unlike a reflector, it is easy to alter the force on a black surface. A solar kite which is made mainly of reflecting material but incorporates some black patches can be controlled in at least two ways.

First, suppose the patches are made of an electrochromic material such as tin/nickel oxide. This substance can be switched from opaque to transparent and vice versa by applying a brief jolt of electricity: switchable sunglasses based on the principle are commercially available. The solar thrust on a given patch is high when it is black, low when it is transparent. If small windows of the material are inset round the kite's periphery, a turning force can be induced by switching their states as required.



An early JPL concept for a Halley's Comet intercept probe. It would have used a 700 m square solar sail and have been launched by the Shuttle in 1985. NASA

Second, suppose each black patch is a solar cell. When no power is being drawn from a cell, all incident solar energy is reradiated as before. But when electricity is drawn, the reradiation diminishes for each watt carried away, and the net force on the cell is reduced. If the solar cells required for power are put on the periphery of the kite, and current is drawn from them selectively, a turning force can again be generated. This method is good because it involves no parasitic mass: a power supply is needed anyway.

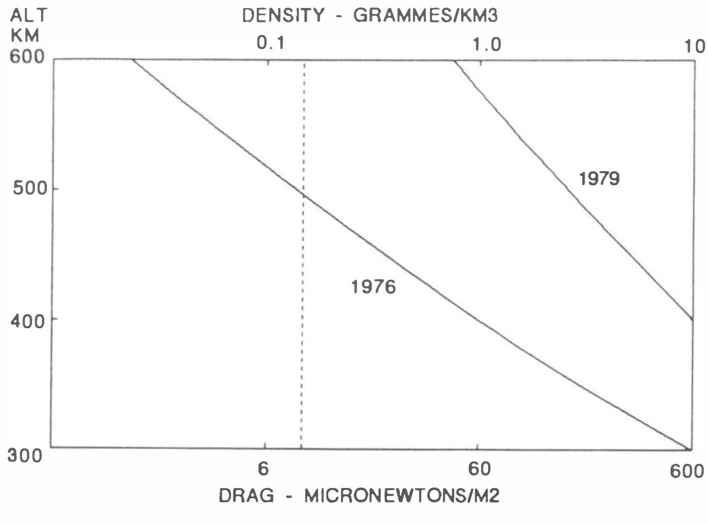
A third way to control the kite is to displace a mass, such as the payload, with respect to the centre of thrust. This can be done neatly if some of the kite's structural members are silvered wires. In vacuo, such a wire is almost perfectly thermally insulated, and a tiny current can easily heat it 100°C or more. This is enough to make it expand about one-quarter percent, sufficient to make the kite turn if the correct design geometry is chosen.

A variety of other effects could be used, but have limitations. For example, electronic switches could be opened and closed to vary the magnitude of the inductive drag on different parts of the kite as it moves through the Earth's magnetic field. However this effect is weak and only works when the sail is moving fast in a relatively strong magnetic field, e.g. close Earth or Jupiter orbit.

Kite Advantages

The kite concept avoids all the problems associated with traditional solar sail designs. Kites are small enough to be deployed by proven techniques, for example opened umbrella-style like a

Figure 2, Atmospheric density from 300 to 600 km (MSIS-86 data set: 13 July 1976 and 19 February 1979 at latitude 50°, longitude 150°, zenith angle 62°).



parabolic radio antenna, or even carried to orbit fully erect in the Shuttle's spacious payload bay. They are fully controllable without needing any moving parts or plumbing. A third advantage is that because they are small, kites are highly manoeuvrable, hence can make progress from a low initial orbit.

This is very difficult for a big sail. Because of its large area, any solar sail is up to one million times more vulnerable to atmospheric drag than an ordinary satellite. At heights of a few hundred kilometres, atmospheric density is small but not negligible, as shown in Figure 2: the top axis is calibrated in grammes per cubic kilometre, the base shows the drag in micronewtons per square metre of profile that an orbiting object incurs at this density. The density of the upper atmosphere varies markedly with the solar cycle, and the two graph lines indicate typical high and low values. A critical point is indicated by the vertical dotted line at 9 μN/m². This is the pressure of sunlight on a reflecting surface: at this point, a sail travelling with the Sun behind it will just balance the drag force on it. For any sail orbiting the Earth, the average solar thrust over a full orbit is at best a fraction of this value, whereas atmospheric drag acts over the whole orbit. So a traditional sail can make progress only at a density many times lower than this, well to the left of the dotted line. It is obvious from the graph that such a sail must be launched far above the ~500 km level which is the

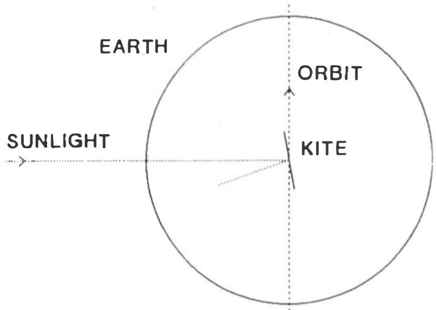


Figure 3. Kite rising from low polar orbit.

maximum height to which the Shuttle regularly flies, and a common choice for microsat orbits.

A kite can do better because it can turn much more quickly than a large sail, and so can be reoriented to maximize the ratio of solar thrust to atmospheric drag at every point of its orbit. The simplest case is when the kite is in polar orbit over the day-night boundary, as shown in Figure 3. If it is tilted almost edge-on to the airflow at a small angle of attack, the drag is proportional to $\sin^3 \theta$, whereas the solar thrust forward component is proportional to θ. For $\theta = 10°$, the drag is just 1/200 of the face-on value, whereas the forward solar thrust is a respectable 1.56 μN/m². The kite can thus make progress from the 'impossible' region to the right of the dotted line in Figure 2: from a density as high as 5 gm/km³, corresponding to an altitude of 375 km in the quiet part of the solar cycle, and only 450 km even near solar maximum. A similar strategy is possible if the kite starts from equatorial orbit: in this case the kite is tilted to produce forward thrust for only the quarter of each orbit when the Sun is most nearly overhead, and trimmed edge-on to the airflow for the remainder.

Kites could therefore be launched as low-cost piggyback payloads, for example from a Space Shuttle 'getaway special' gas-can. Built from commercially available components, a kite could be flown at a cost of a few hundred thousand dollars, without requiring backing from the big space agencies. This may be critical to gaining acceptance for the concept, and I would be interested to hear from any person or institution who might be interested in funding such a demonstration. In a sequel to this article I shall give details of a minimalist kite design, which I have dubbed *Mobile Observer Using Solar Effects* in honour of the original Mouse (Minimum Orbital Unmanned Satellite of Earth) which Arthur C. Clarke and colleagues at the British Interplanetary Society proposed in 1951. Carrying only a tiny electronic camera and low bit-rate radio as payload, this craft will nevertheless be capable of some ambitious missions, including rendezvous with a near-Earth asteroid and transmission of close-up pictures.

Colin Jack is an inventor with extensive experience in the aerospace and computing industries. He has a strong interest in alternative space launch and propulsion technologies.

'Planetary Probes' Competition

Of the eight major planets of the Solar System (apart from the Earth), Pluto is the only one not yet visited by a planetary probe. For the remaining seven there was that all important first spacecraft flyby, which often provided an astonishingly new insight into another world.

This month's competition focusses on the names of the spacecraft that achieved these first planetary fly-by missions and provides an opportunity for readers to recall these events and perhaps win a prize.

Prizes: The first four correct entries to be opened after the closing date of 1 December 1994 will receive a copy of the video*:

A Collection of the "Movies"

(This video features four short productions which use satellite/space probe images and supercomputer graphic animation.)

To Enter: Supply the names of the planetary probes that made the first fly-by missions to:

1. Mercury ....
2. Venus ....
3. Mars ....
4. Jupiter ....
5. Saturn ....
6. Uranus ....
7. Neptune ....

Title/Name ....

Address ....

....

....

Post to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England
To arrive by first delivery on 1 December 1994.
Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.
* Tapes are VHS PAL format only and are not compatible with the US NTSC system.

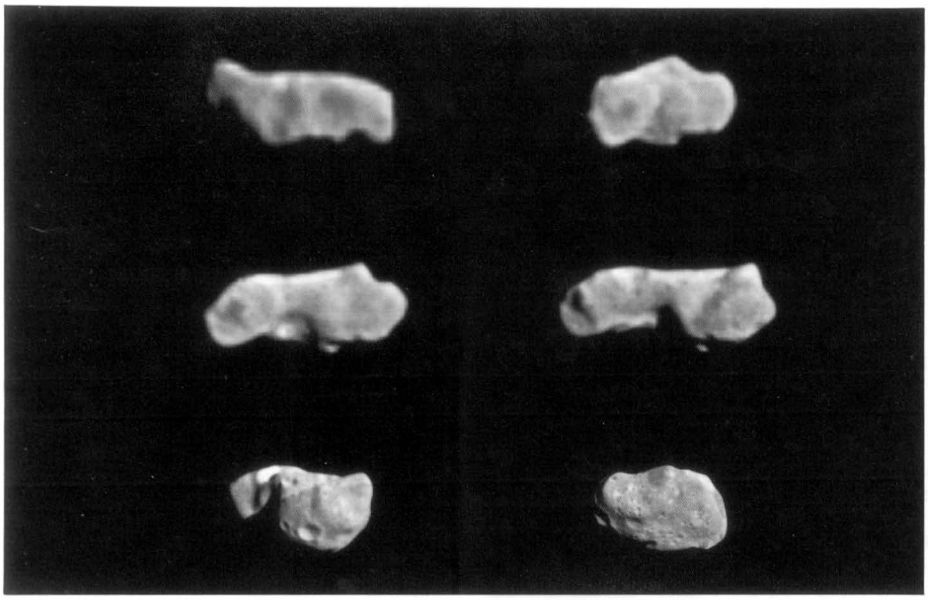
Ida Rotation

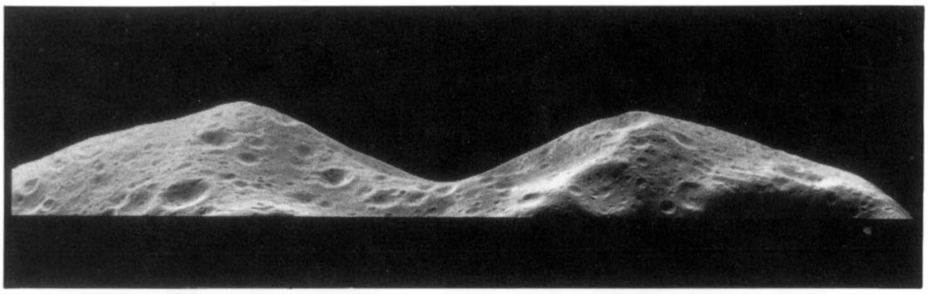
The composite image below shows Ida as seen from the Galileo spacecraft during its approach on 28 August 1993. The six views were shuttered through the camera's green filter and show Ida's rotation over an interval of about 3 hours 18 minutes. The asteroid makes a complete rotation every 4 hours 38 minutes; therefore, this set of images spans about 3/4 of Ida's rotation period and shows most of Ida's surface. By combining the information in these views with that from the highest resolution images returned from the spacecraft (see right) the size and shape of this irregular body can now be determined accurately. The asteroid appears to be about 58 km long and about 23 km wide, with a very irregular shape and volume of some 16,000 km^3.

The images are arranged in chronological order from a time 3 hours 51 minutes before closest approach (upper left), through upper right, middle left, middle right, lower left, and lower right (33 minutes before closest approach). The six images show Ida at the same scale throughout.

Ida's rotation axis is roughly vertical in these images, and the rotation causes the right-hand end of Ida to move toward the viewer as time progresses. The first image was taken from a range of about 171,000 km and provides an image resolution of about 1,700 m per pixel (the highest resolution achieved for Ida is about 25 m per pixel). The second, taken 70 minutes later, is from 119,000 km, followed by 102,000 km, 85,000 km, 50,000 km and 25,000 km. The features on Ida are less sharp in the earlier views because of the greater distances.

Prominent in the middle views is a deep depression across the short axis of the asteroid. This feature tends to support the idea that Ida may have originally been formed from two or more separate large objects that collided softly and stuck together. Also visible in the lower left view is an apparent linear albedo or reflectance boundary. Colour images yet to be returned from the Galileo spacecraft may help resolve the question of whether or not the two ends of Ida are made of different materials. JPL





Highest Ever Asteroid Resolution

The Galileo imaging system captured the above picture of the limb of the asteroid 243 Ida about 46 seconds after its closest approach on 28 August 1993 from a range of only 2480 km. It is the highest-resolution image of an asteroid's surface ever captured and shows detail at a scale of about 25 m per pixel.

The image is one frame of a mosaic of 15 frames shuttered near Galileo's closest approach to Ida. Since the exact location of Ida in space was not well-known prior to the Galileo flyby, this mosaic was estimated to have only about a 50 percent chance of capturing Ida. Fortunately, this single frame did successfully image a part of the sunlit side of Ida. Prominent in the view is a 2 km deep "valley" seen in profile on the limb. This limb profile and the stereoscopic effect between this image and the full-disk mosaic will permit detailed refinement of Ida's shape in this region. This high-resolution view shows many small craters and some grooves on the surface of Ida, which give clues to understanding the history of this heavily impacted object. JPL

'Ulysses Spacecraft' Competition Winners

Winners to whom book prizes will shortly be dispatched are:

N. Angold	USA
T. Chance	Republic of South Africa
M. Degner	USA
T. Pribyl	Czech Republic

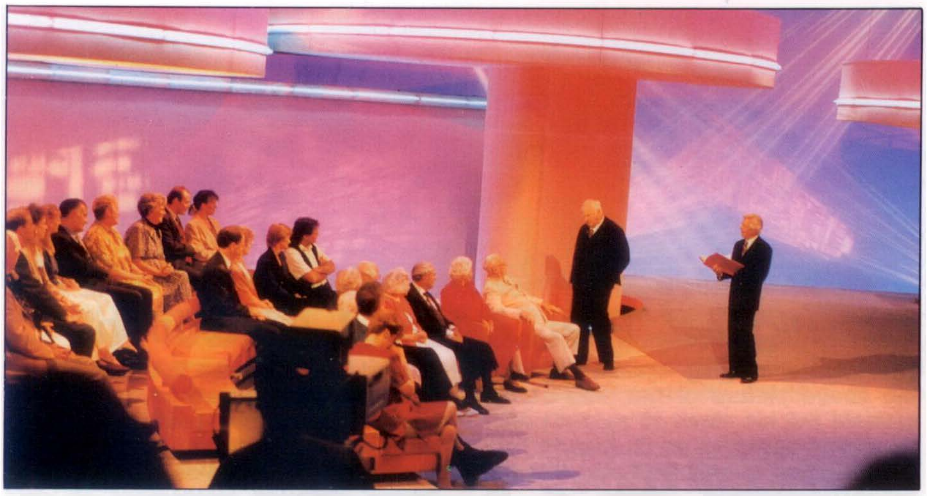
The correct answers are: 1. H; 2. G; 3. D; 4. K; 5. L; 6. F; 7. E; 8 A; 9. J; 10. I; 11. C; 12. B.

Ida Moon

Most Detailed Picture

This image is the most detailed picture of the recently discovered natural satellite of Ida taken by the Galileo Solid-State Imaging camera during its encounter with the asteroid on 28 August 1993. Shuttered through the camera's broadband clear filter as part of a 30-frame mosaic designed to image the asteroid itself, this frame fortuitously captured the previously unknown moon at a range of about 3,900 km, just over 4 minutes before the spacecraft's closest approach to Ida. Each picture element spans about 39 m on the surface of the moon.

More than a dozen craters larger than 80 m in diameter are clearly evident, indicating that the moon has suffered numerous collisions from smaller Solar System debris during its history. The larger crater on the terminator is about 300 m across. The satellite is approximately egg-shaped, measuring about 1.2 x 1.4 x 1.6 km. At the time this image was shuttered, Ida was about 90 km away from the moon, outside this frame to the left and slightly below centre. This image was relayed to Earth from Galileo on 8 June 1994. JPL



Patrick Moore greets Arthur C. Clarke (seated) with a few reminiscences as TV show presenter Michael Aspel looks on. CHARLES ADAMS*

Arthur C. Clarke - 'This is Your Life'

BIS members were among the many long-standing friends presented to Arthur at the BBC Television Centre's 'This is Your Life' programme in late August. *Mat Irvine* was one of those there and fills in the details.

Considering that a week in late August spent in London, while returning to Sri Lanka from the USA, was ostensibly a private visit for Arthur C. Clarke, he managed to fit in an amazing number of appointments. Besides meetings with producers of various projects that he is currently involved in; plus a visit to Stanley Kubrick, the producer, director and his co-writer of *2001 - A Space Odyssey*; he was also presented with a copy of the script for the current movie version of his novel *A Fall of Moondust*, now in pre-production. In addition he was a surprise guest at a Star Trek and Science Fact convention, along with actor Patrick Stewart (Captain Picard), much to the delight of the 700 strong audience who gave him a standing ovation. This was repeated when it was revealed that he had been nominated for this year's Nobel Peace Prize for his, in effect, invention of the communications satellite.

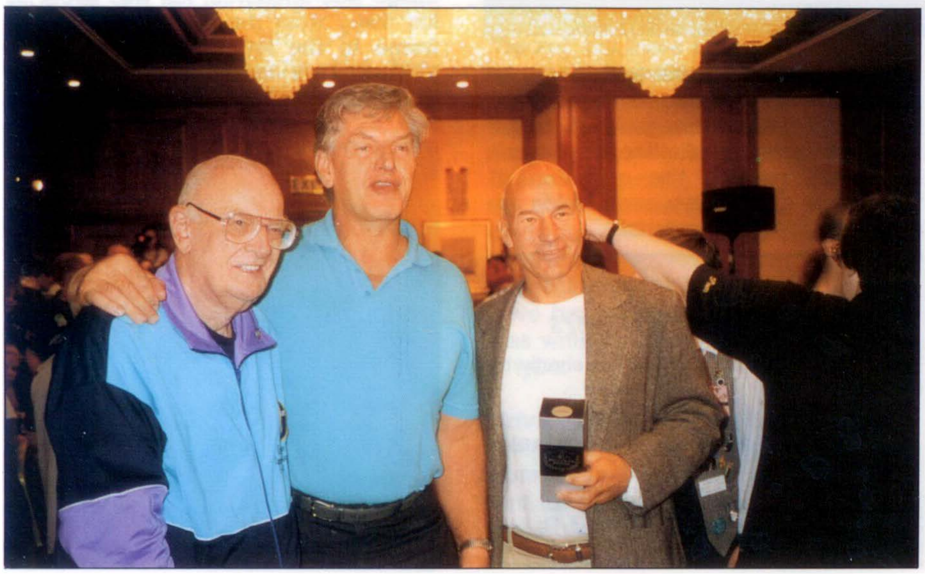
However what Arthur himself was not aware of was the behind the scenes activity involved with a visit to the Science Museum on the Thursday. This was ostensibly for some filming for his next 'Mysterious World' TV series, but was really a ploy to have a TV camera at the ready, for while walking around the Space Gallery, he was suddenly confronted with an old friend of his - Buzz Aldrin. Only just getting over this, an even bigger surprise was the approach of Michael Aspel with that Big Red Book, for Arthur C. Clarke had been chosen to have his life revealed and celebrated for the new series of *This Is Your Life*.

Taken to BBC Television Centre for the main recording, Arthur was then presented with a flow of friends from past years and the present. These included not only the second man to walk on the Moon, but also Alexei Leonov, the first spacewalker, who presented Arthur with a poster signed by all the astronauts and cosmonauts of the current world space programmes. Other guests included Patrick Moore and Heather Couper, plus the majority of the rest of the Clarke family. Sir Edward Fennessy, Arthur's commanding officer in the RAF, related how he got Arthur involved with these new-fangled radar projects while the programme even brought in Arthur's original science teacher, Bobby Pleass (who has sadly died since the recording), who confessed that he always thought Arthur knew more than he did about the subject.

The finished programme is due to be one of the first stories for the return of the long-running series back to the BBC, where it all started. Transmission should be in November.

MAT IRVINE

Other visits for Arthur C. Clarke during the week-long stay in London included an unscheduled visit to "ARCHON '94", a Star Trek and Science Fact convention held at the Raddison Edwardian Hotel near Heathrow. Also present were David "Darth Vader" Prowse (centre) and Patrick "Captain Jean-Luc Picard" Stewart (right). MAT IRVINE



Arthur C. Clarke (centre) with two long-standing friends Alexei Leonov (left) and Buzz Aldrin (right), with their respective wives, after the recording of 'This is Your Life'. CHARLES ADAMS*

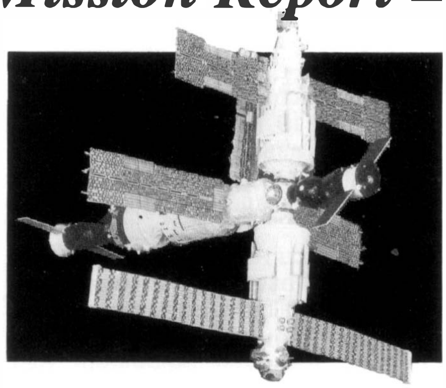
At the party after the recording, there were still some surprises for Arthur C. Clarke. Alexei Leonov, presents him with a series of gifts - including a samovar as a personal present from himself and his wife, Svetlana. Arthur's brother, Fred Clarke, is holding the samovar received from Svetlana Leonov. MAT IRVINE

** Copies of these photographs in colour may be obtained from Charles Adams, 102, Linden Way, Southgate, London, N14 4NH (Tel: 081 882 5878). The price is £2.50 each plus postage, the proceeds being given to Charity.*

Activities at Mir

January - July 1994

Russian-Kazakh Crew Takes Over Mir



At 1225 GMT on 1 July 1994 the Russians launched their second manned spacecraft of the year. The two-man Soyuz TM-19 ship carried Russian Yuri Malenchenko and Kazakh citizen Talgat Musabayev. As well as conducting the normal range of scientific experiments, the two cosmonauts were to conduct specific military tasks to combat terrorism, a role that harps back to the early Almaz programme with an all-military reconnaissance crew. The launch was conducted from the Baikonur cosmodrome in Kazakhstan.

Introduction

Amid the on-going controversy regarding the Russian lease agreement for use of Baikonur there was much interest in the monetary charge which the Russians would make for the flight of Musabayev.

The Kazakh authorities had declared that Musabayev, a Colonel in the Russian Air Force, would make his flight as a Kazakh citizen. However, because of the recalcitrance of the Kazakhs in agreeing details for the lease of the cosmodrome, the Russians said that they would charge the Kazakh government for the cosmonaut's expected four-month stay on the Mir station. In the end a deal was agreed but no public statement was made saying just how much money had changed hands.

The new pair of cosmonauts were to take over the operation of the orbiting Mir complex from cosmonauts Viktor Afanasyev and Yuri Usachev who had been launched with Doctor Valeri Polyakov on 8 January 1994. The doctor, on his way to setting a space flight duration record of 14 months, remained on the complex with the new pairing while the original crew returned home.

During their long orbital shift the Afanasyev crew had conducted numerous observations of the Earth and of an astronomical nature in a wide-ranging experimental programme. The main thrust of the flight of Dr Polyakov lies in making medical studies of himself and his adaptation to weightlessness during the longest space mission attempted to date.

An expected extravehicular activity by Afanasyev and Usachev to inspect possible damage inflicted to the Kristall module during the undocking of the previous crew on 14 January was not forthcoming. Instead the men made long-range observations of the complex during a re-docking manoeuvre of their Soyuz TM-18 craft in January.

Afanasyev Crew at Work

The crew consisted of Viktor Afanasyev, Yuri Usachev and Dr Valeri Polyakov. They were the 15th main expedition to the station (EO-15). Their launch, expected in November 1993, was delayed due to payment problems between the enterprise making the engines of the Soyuz carrier rocket and the Russian government. The cosmonauts assumed control of the complex from the two crewmen of EO-14 - Vasili Tsibliyev and Aleksandr Serebrov. *(For a listing of expected crew changes at Mir up to the end of 1995, see **Spaceflight**, May 1994, p.156.)*

All EO-15 cosmonauts were amateur radio operators and used the Mir's ham radio facilities during the mission.

An early task for the cosmonauts, and one of the highlights of the mission, was the re-docking of the Soyuz TM-18 ferry ship in which they had arrived at the complex from the rear Kvant port to the front axial port of the Mir base block. This operation would free the rear port for the arrival of several unmanned cargo ships.

BY NEVILLE KIDGER, FBIS
Leeds, UK

At 0312 (all times GMT) on 24 January the TM-18 craft, with the three men aboard it, was undocked from the Kvant port. It backed off to a distance of 130 - 150 metres and then Afanasyev began a slow flight around the complex. While doing this, the cosmonauts observed and photographed the site of the collision between Soyuz TM-17 and the Kristall module. The cosmonauts re-docked TM-18 with the front port of the base block at 0501 and re-entered the complex.

Progress M-21 in Flight

The first re-supply craft to be launched to the EO-15 crew was Progress M-21, at 0212:10 on 28 January. The launch, using a Soyuz carrier rocket from Baikonur placed the unmanned cargo spacecraft in a 236 x 194 km orbit with a period of 88.5 minutes. Over the next two days the craft was manoeuvred to rendezvous with the Mir complex and docking with the Kvant port was successfully accomplished at 0356 on 30 January.

In addition to unloading the usual consumables and scientific instruments, the cosmonauts fitted the newly arrived components into the complex to replace outdated or worn out ones.

The scientific investigations underway included surveys of stellar X-rays and studies of the Earth's atmosphere to assess the degree of absorption of ultraviolet radiation. Radiation levels on the station were being measured by the French-made Nausica device. Regular monitoring of the flow of elementary high-energy particles of cosmic origin and seismic events on Earth continued using the Maria magnetic spectrometer, a device with a long history of use on both the Salyut and Mir programmes.

Medical and technical experiments were conducted for the German Space Agency as an extension of the "Mir-92" mission of Klaus-Dietrich Flade and the German Space Control Centre at Oberpfaffenhofen near Munich was linked for voice, data and video relays from the Mir station in real time. The hardware for one of the experiments used by Dr Polyakov - code-named VOG - had been provided by the Kayser-Threde company of Munich (***Spaceflight***, May 1994, p.155).

Progress M-17's Demise

By 15 February the unmanned Progress M-17 craft which had been undocked on 11 August 1993 - after a 132 day flight with the complex - and which had been left in orbit for extended duration tests of its systems was reported to be in an orbit of 273 x 227 km with a period of 89.2 minutes and an inclination of 51.6 degrees.

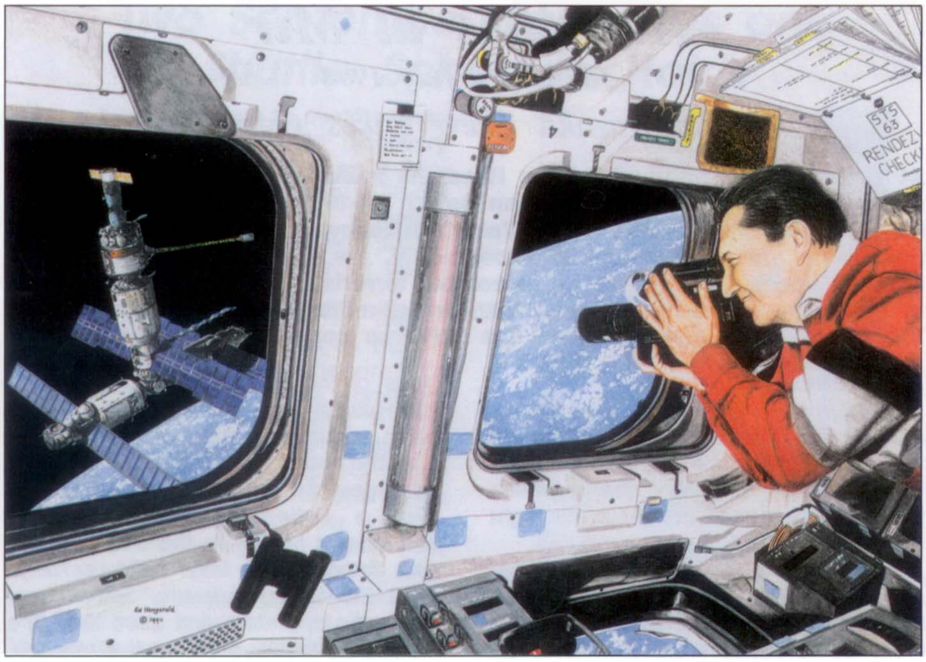
At 1500 on 2 March the engine of Progress M-17 was fired to put the craft into a lower orbit of 172 x 149 km and at 0328 the next morning the craft re-entered the atmosphere near to Manila in the Philippines where it was destroyed during the descent.

During 3 March, the manoeuvring system located atop the 14-metre tall Sofora girder was put through tests of its activation sequence.

Over the following days the men returned to their routine experiments until 10 March when the trajectory of the complex was altered by firing the Progress M-21 engine.

Progress M-22 Launched after Fire at Cosmodrome

During his visit to Baikonur on 20 March, the American Secretary of Defense William Perry was able to view preparations on the launch pad for the launching of the next un-



Ed Hengeveld looks forward to the forthcoming Shuttle-Mir missions and depicts the early 1995 STS-63 fly-by mission in this painting in which Cosmonaut Vladimir Titov uses a 70 mm Hasselblad camera with a telephoto lens to photograph the Mir space station from one of the overhead cockpit windows of the Space Shuttle Discovery. ED HENGEVELD 1994

manned cargo craft to re-supply the Mir complex - Progress M-22.

The launch had initially been planned for 19 March but, following a fire at the assembly building on 7 March and heavy snow falls, the craft was eventually launched at 0454 on 22 March.

The fire occurred in an annexe to one of the MIK assembly buildings and spread to a military unit command and control headquarters which served the MIK. Although equipment was damaged beyond repair in five rooms which were gutted there was no irreparable loss of testing equipment, according to cosmodrome sources.

The fire was the result of staff negligence claimed ITAR-TASS and the problems in controlling the fire were made worse by an acute water shortage and the blockage of roads and rail lines by snow. Incidents such as this were becoming usual, a correspondent wrote, and the Russians were finding it unprofitable to send new equipment to the cosmodrome because such equipment becomes the property of the Kazakh government once at the cosmodrome.

At 0120 on 23 March the Progress M-21 craft was undocked from the Kvant port and was de-orbited to be destroyed in the upper atmosphere later the same day. The undocking cleared the Kvant port for the M-22 craft to dock at 0640 the next day.

On 29 March the KFA-1000 camera was used to take pictures of the Earth's surface and Dr Polyakov took more noise level readings to investigate the acoustic and electromagnetic interference caused in the compartments of the complex by the operation of equipment.

At the end of March, as reported by *Aviation Week and Space Technology*, the cosmonauts used an electron beam gun mounted on Mir to fire electrons towards the Swedish Freja satellite. The Swedish satellite operates in an 1100 km high orbit and the one minute initial firing of the electron beam gun was timed to coincide with the passage of both space vehicles through the Earth's magnetic field at a particular location. At the time, Mir was travelling northeast towards the Alaskan coast. A ground station at Prince Albert in Canada was to monitor the test for scientists in Russia, Sweden and Germany.

The Kvant module seen here on the right at the Cosmonaut Training Centre (TsPK) at Star City. On the left is the Kristall module. A description of the Mir space station and its component modules appears on p.305 of the September issue. KARL HEINZ ROHRWIND

Extra Time in Orbit

On 17 May, Ekho Radio from Moscow reported that there was the possibility of a delay to the launch of the next crew - the EO-16 crew - on the Soyuz TM-19 craft because of difficulties with the production and testing of the fairing for the Soyuz carrier rocket. The Soyuz spacecraft is encapsulated in the fairing during the first minutes of launch and the fairing also houses the tower and deployable petals of the Launch Escape System. A delay would mean that, for the second successive mission, the replacement crew would be late in arriving at the Mir station and the crew already on the station would have to spend extra time in space.

Meanwhile the present crew continued their orbital experiments and maintenance work. In particular they took measurements of the various temperature fields of the Gallar furnace, which was in regular use to smelt gallium arsenide crystals, in order to determine the best conditions for the production of monocrystalline semiconductors.

By 20 May the Russians announced that the mission of the cargo ship Progress M-22 was nearing its completion. The crew had loaded used equipment into its empty cargo section and the process of refuelling the Mir base block engines had been completed.

Progress M-23 Flight

On 22 May the Russians launched the Progress M-23 cargo spacecraft at 0330:02 from Baikonur on a Soyuz-U booster into a 247x192 km orbit with a period of 88.6 minutes. The unmanned

craft was to deliver 2207 kg of equipment and carried a Raduga recoverable capsule.

On 23 May at 0057 Progress M-22 undocked from the complex and was later destroyed in the upper layers of the Earth's atmosphere, as planned. The next day, 24 May, saw Progress M-23 dock with the recently vacated port at 0600.

During 27 May the crew carried on with the Priroda-5 camera surveys, which aimed at determining the ecological condition of land and water basins in central and southern Russia and forest tracts in Eastern Siberia. Also on 27 May it was announced that the TM-19 launch had indeed been delayed from 20 June to 29 or 30 June. The announcement was made by Col-General Vladimir Ivanov, the Commander of the Russian Military Space Forces.

On 3 June, Russia Radio announced that the launch of Soyuz TM-19 had been rescheduled for between 1 and 5 July.

Row Over Status

On 8 June Russian TV reported that a row had broken out between Russia and Kazakhstan over the status of Lt-Colonel Talgat Musabayev, the prime flight engineer of the Soyuz TM-19 flight. Musabayev, a "Kazakh by nationality" is a member of the Russian Air Force but the Kazakh authorities were insistent that the cosmonaut flew into space as a Kazakh citizen and not as a Russian officer. The TV report said that the Russians agreed but this meant that Musabayev would be treated as a foreigner and the Kazakhs should pay $150 million to cover the cost of his 4-month stay in space.

ITAR-TASS reported on 17 June that the upcoming mission was to be treated as a commercial one with the Russians and Kazakhs splitting the cost of the joint flight, but no financial details were given. Musabayev told the press that the Kazakhs would pay in cash for equipment and expendable materials whilst the rest of the money would count as payment for the Russian rent of the Baikonur facility.

Malenchenko and Musabayev were to be the first rookie crew to be launched in the Soviet/Russian programme since the Soyuz 25 mission in 1977 which failed to dock with the Salyut 6 space station and heralded a Resolution stating that each crew would have to have at least one experienced cosmonaut. The mission was scheduled to last for 130 days.

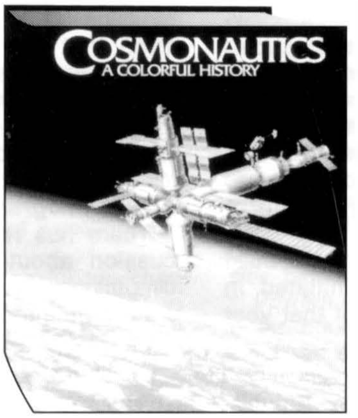
The main thrust of the mission was to concentrate upon Earth observations, ecological studies and hydrology and it would also be doing work for the defence ministry in support of the state security and, in particular, "for international security and perhaps combating terrorism". Malenchenko and Musabayev are both pilots and have undergone higher education in aviation engineering.

In the reserve crew were Aleksandr Viktorenko and Yelena Kondakova, who is an engineer with the Energiya NPO. She will be only the third Russian woman to fly in space and the first woman for whom an extended space mission is scheduled.

Soyuz TM-19 Details

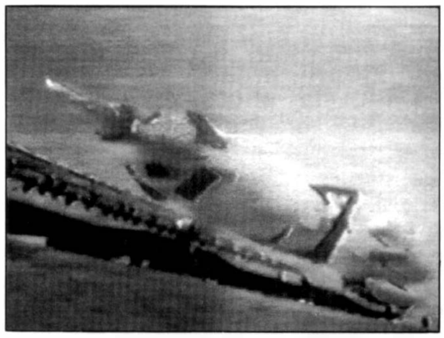
Soyuz TM-19, carrying Malenchenko and Musabayev, was launched at 1225 on 1 July. Progress M-23 undocked at 0847 on 2 July and was de-orbited the same day with the safe recovery of the Raduga capsule. The TM-19 craft docked with the rear port of the Kvant complex at 1355 on 3 July. During the next five days the EO-15 crew handed over the station to their successors.

Soyuz TM-18 with Afanasyev and Usachev landed at 1033 on 9 July. The two cosmonauts had spent 182 days and 27 minutes on their flight. For Polyakov, of course, his time in orbit continues to accumulate towards the record. ■



Soviet Circumlunar Programme Hardware Revealed

Further recent information has come to light on the former USSR's circumlunar programme and space vehicle configurations. *Peter Pesavento* **has the details.**



This still from a GLAVKOSMOS promotional film marketing the Proton rocket has been identified as among the first photos released of the Proton/7K-L1 configuration of the Soviet circumlunar programme. Of special interest is that in the original film, the rocket - with the exception of an olive-green first stage - is painted all white. The red Soviet flag painted on the nose fairing just above the black speed brakes indicates that this is a view of the rail transport of an actual flight-ready booster.

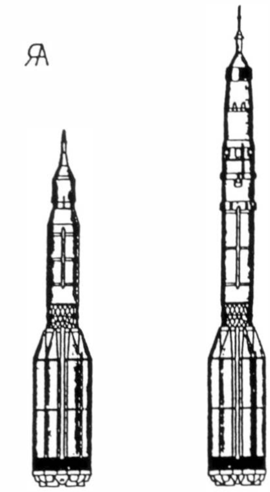
GLAVKOSMOS (VIA MICHAEL CASSUTT)

Chelomei's Spaceship

It is known that in the Soviet circumlunar programme two design bureaux - Chelomei's OKB-52 and Korolev's OKB-1 - were vying for control. Up to now, little has been known about the actual configuration of Chelomei's spacecraft, that is until in a recent Russian publication [1] its configuration was revealed.

The small craft (it was to have carried one man) looks somewhat like a Command Service Module of the Apollo project. The radio antennas as well as the solar panels were not directly parallel to each other, but were put at an offset stance. Comparative measurements indicate that the length of the spacecraft was 5.2 m and that the length of the space capsule (that would have housed the cosmonaut) was about 2.7 m. The solar panels were about 7.27 m in length. Previous attempts by Western space observers to put together a Proton launcher/spacecraft configuration have been drawn on the assumption that the Chelomei Proton booster and the Korolev booster configurations would be nearly the same size. However the recent information [1] shows that the Chelomei version of a circumlunar rocket was about 1/3 smaller and comparative analysis indicates that the Chelomei version was approximately 46.7 m tall, compared to the actual 7K-L1 configuration of about 63 m length.

Even though the go-ahead to build the spacecraft was only initiated in early 1965, by September of that year



Comparison of Proton/spacecraft configurations of Chelomei OKB (left) and Korolev OKB (right). Chelomei's design seated one person, Korolev's two.

BY PETER PESAVENTO
California, USA

the Chelomei bureau had already a dozen lunar spacecraft under construction [2]. It was on Christmas Day 1965 that the Korolev bureau managed to wrest away control of the circumlunar project from OKB-52, contributing to the bitterness between the two great spacecraft designers.

7K-L1 Programme

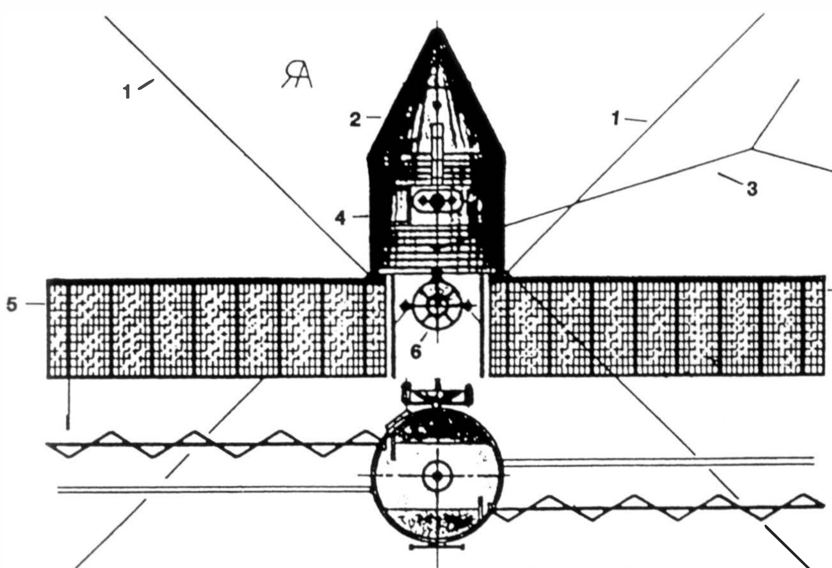
There has recently been some discussion about whether the manned circumlunar programme of the USSR was cancelled after the failure to launch an attempt to upstage Apollo 8 in early December 1968 [3]. It has been revealed that the upstaging attempt's actual launch date was 9 December [1]. This same Russian article outlines the state of affairs following the cancellation of the launch and the successful Apollo 8 mission:

> "After that, at the beginning of 1969, the UR500K-L1 [the manned circumlunar project] piloted programme nearly ceased to exist - the spacecraft 7K-L1 in its piloted form was abolished, while the remaining spacecraft components were made good use of by having separate [sub?] systems paying for themselves [elsewhere, in other projects]."

There is no doubt that Korolev's successor Vasiliy Mishin and OKB-1 wanted to have another chance at sending men around the Moon, having come so close in early December 1968. Whether the ideas of an uncrewed mission in December 1969 and an actual manned voyage for Lenin's birthday celebration were more than mere paper studies, only the Russians with further disclosures can answer.

To date no clear picture has been released by the Russians of the Proton/7K-L1 configuration. In a promotional videotape by Glavkosmos on the Proton rocket and its capabilities, Phil Clark identified two scenes showing the circumlunar configuration. (The film itself did not point out such significances). A still from the video is shown above.

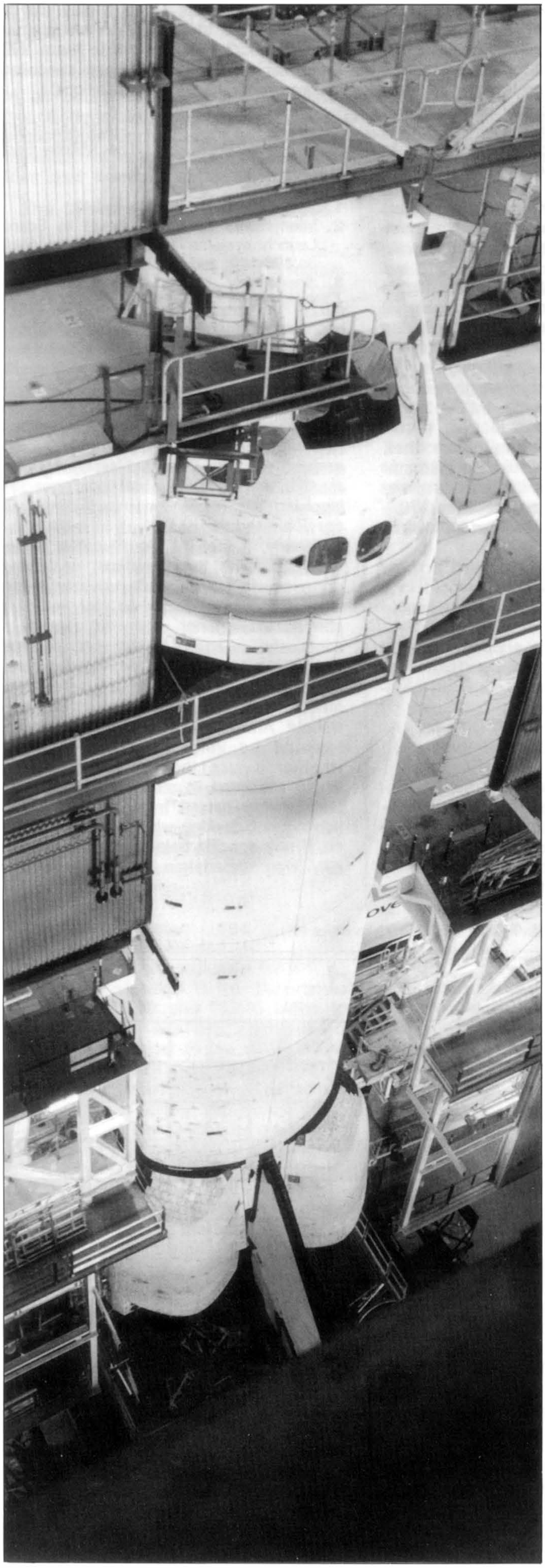
Lunar orbiting spacecraft, the Chelomei OKB: 1. Radio antenna; 2. space capsule; 3. magnetometer boom; 4. propulsion/attitude module; 5. solar panels; 6. microwave altimeter (to be used when in lunar orbit).



Drawings by A. YASINSKOVO

References

1. I.A. Marinin and S.H. Shamsutdinov, "Sovestkiye Programmiye Poletov K Luniye", *Zemliya i Vselennaya*, (4), pp.62-69, 1993.
2. Michael Cassutt, Personal communication with the author, January 12, 1994.
3. B. Hendrickx, Correspondence, "Soviet Manned Lunar Programme", ***JBIS*, 46**, pp.207-208, 1994.



KSC Visitors

Above: **A chat with the crew of the STS-64 Discovery mission during their Terminal Countdown Demonstration Test (TCDT).** *Left to right:* **Dick Richards, Blaine Hammond, Susan Helms and Jerry Linenger. Only partly visible: Carl Meade and Mark Lee.** E. RUDOLF VAN BEEST

Left: **Space Shuttle Discovery seen on 18 August from the 16th floor of the VAB, one day before its roll-out for mission STS-64.**
E. RUDOLF VAN BEEST

Sir, In August I visited the Kennedy Space Center. It was my intention to attend the launch of the STS-68, Endeavour, but, as you know, there was a main-engine cut-off and it was a very disappointing experience. However, meeting astronauts, staying at the pads 39A and B, visiting the VAB etc were very exciting events.

I took the enclosed photos (above and left). The pictures are in fact very topical because they concern the STS-64 Discovery mission.

E. RUDOLF VAN BEEST
The Netherlands

Acclaimed author Arthur C. Clarke attended the aborted launch of space shuttle Endeavour on 18 August. He was there to discuss NASA's involvement with the Dian Fossey Gorilla Fund which monitors a group of rare African mountain gorillas in war torn Rwanda. NASA will use the radar mapper to be carried aboard STS-68 to map the cloud shrouded area. The last ground trackers were evacuated in April. It was noted that gorilla-related tourism was Rwanda's third largest source of income.
PETER GUALTIERI/WEST KENTUCKY NEWS

Astronaut YYYY-nnnX

Sir, As can be seen monthly in ***Spaceflight*** on the pages of *Satellite Digest*, each satellite launched gets an international designation of the form YYYY-nnnX, where YYYY stands for the year, nnn is the number of the launch within that year and X is a letter which, in case of a multiple launch, is A for the first payload released, B for the second one etc.

On the recent STS-64 flight, the shuttle Discovery would thus receive a designation like 1994-nnnA and the temporarily released Spartan satellite the designation 1994-nnnB. Later on in the flight, two astronauts performed an untethered spacewalk on which they technically became satellites in their own right.

My question - out of pure curiosity - is: Does anybody know whether the two free-flying STS-64 astronauts (and also any of the former MMU astronauts) received individual satellite designations (maybe with letter extensions C and D)?

GERHARD HOLTKAMP
Darmstadt, Germany

Use Buran and Energiya

Sir, I was very disappointed to learn about the fate of Buran mentioned in Mr Breed's letter [1]. In fact I talked to Cosmonaut Valery Poliyakov on board the Mir orbital station asking him about the fate of Buran via ham radio on 26 July. He mentioned that there was no money and that there were attempts to save the project.

My personal view is that moving a flight worthy model of Buran to Gorky Park is a very provocative action probably aimed at discrediting the whole programme which is definitely not in the interests of space exploration in general. Dozens of much less costly prototypes of spacecraft and aircraft have had a much more respectable retirement either in museums or institutes. The airframe at Gorky Park might preferably have been taken to the Cosmos Pavilion and displayed there to save what scientists and technicians have given so much devotion, time and effort to after abandoning the G-booster programme.

The best opportunity for using the Energiya/Buran system could have come from a more reasonable agreement regarding the International Space Station.

First: The core module of such a station that represents human achievement into the 21st century should preferably been a POLYUS type module launched by Energiya instead of a Salyut tug module which is an inherently old design for a 21st century space station. The additional costs could be justified if political pressure were put aside letting pure scientific reason prevail.

Second: The 51.6 deg inclination of the station makes Buran an attractive partner to the US Shuttles in space station construction giving it an approximately 50 percent advantage in payload capacity [2]. This also comes as an answer to Mr Beswick's letter [3] as he was proposing a US Shuttle for the Mir modules. No payload analysis was given but according to my information, the Shuttle is not capable of putting a 20 ton payload into a 400 km orbit at 51.6 deg inclination. About 7 tons of payload capacity is lost just by reaching 400 km with additional loss coming from the inclination change to 51.6 deg. The cradle support required could be borrowed or modified from those used for Buran which were designed to accommodate Mir type modules, expecting some compatibility with Shuttle cargoes.

The Shuttle station assembly flights could then be reduced from 15 flights [4] to about 10-12 if Buran were given the opportunity to contribute at a rate of one flight for every 2-3 US Shuttle flights. The expected operational Energiya/Buran costs are likely to be less than a US Shuttle launch especially in view of the current Russian economy. After that, serious consideration could be given to the use of Energiya in international lunar and interplanetary manned and unmanned missions, in addition to launching giant comsats.

I note that ESA has proposed a study for returning to the Moon presented in a recent workshop. The Energiya could play a prominent role in such missions.

Third: The hardware support prepared for Energiya/Buran makes its cancellation a serious blow to the Russian aerospace industry that could effect their long term capabilities. The MAKS project would be more credible had there been flight experience with Buran.

Also it must be noted that the Kaliningrad Spaceflight Centre had a new control hall built specifically for Energiya Buran missions in addition to the well-known control hall shown regularly during Mir-Soyuz and planetary missions. This makes it a unique centre in the sense that it can handle two major events simultaneously. Should such a centre play only a secondary role to Houston in an international project? It is ironical to learn that Buran-Mir missions have been cancelled in favour of US-STS-Mir missions.

M.Q. HASSAN, FBIS
The Middle East

References

1. ***Spaceflight***, July 1994, p.249.
2. International Reference Guide to Space Launch systems 1991 Edition by AIAA pp.106-119 and pp.246-261.
3. ***Spaceflight***, March 1994, p.93.
4. ***Spaceflight***, May 1994, pp.147-151.

Solo LM Ascent?

Sir, I was interested to read in ***Spaceflight***, July 1994, the letter entitled 'Solo Spacewalks' by Laurenc Svitok; and the reply by Dietrich Haeseler, where mention is made of abort contingencies involving the Apollo lunar and command service modules.

Clearly, if the LM were unable to ascend from the lunar surface, or having done so, failed to rendezvous with the CSM, the command module pilot would be able to leave lunar orbit and execute a successful re-entry, by himself. Michael Collins, in his book, *Carrying the Fire*, remarks that he would be forever a marked man if he had to return to Earth without Armstrong and Aldrin. However, I would be very interested to know whether it was thought feasible for a single astronaut to manage the LM systems during ascent from the Moon and subsequent docking with the CSM and, if so, if any specific training for this eventuality was undertaken.

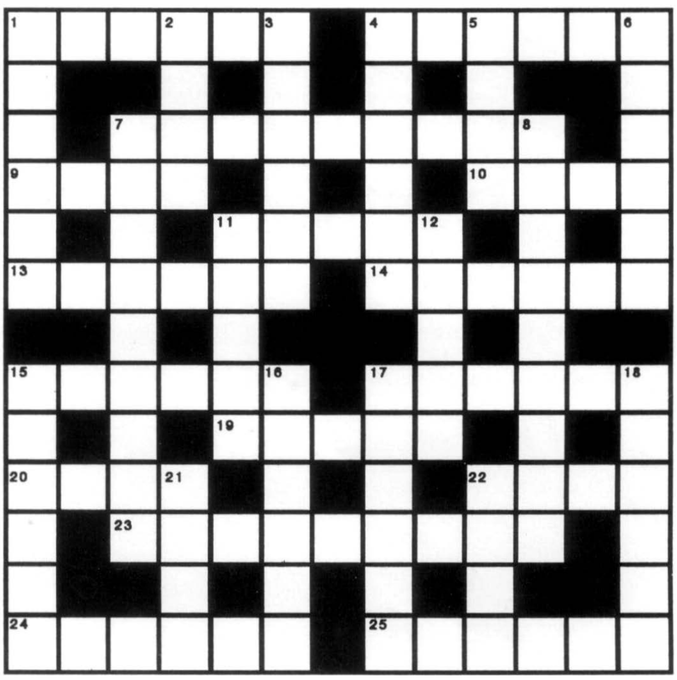
BEN FARROW
Uxbridge, UK

Spaceflight Crossword

No. 15

ACROSS
- 1+4. Double star seen by telescope (6,6)
- 4. See 1. Across
- 7. Pertaining to a type of orbit
- 9. Grassed surface
- 10. Scowl
- 11. Propels
- 13. Portion of space
- 14. Suitable
- 15. Edible crustaceans
- 17. Lathe worker
- 19. Horizontal baseline for height measurements
- 20. Calcium compound
- 22. Apollo astronaut
- 23. Heat ———
- 24. Group of six
- 25. Contrivance for descent from Lunar Module

DOWN
- 1. One-dimensional array
- 2. Organisation whose Manned Orbiting Laboratory was cancelled in 1969
- 3. Heavy
- 4. Meditates silently
- 5. Pin down
- 6. Annual
- 7. Schedule of events
- 8. Head crewmember
- 11. Probe
- 12. Component of blood
- 15. Asteroid
- 16. Shampoo container
- 17. Subterranean passage
- 18. Lunar impact probe
- 21. Computer operator's last command
- 22. Curve



Solution will appear in the December issue.

Solution to Crossword No.14.

ACROSS: 1. Polar; 4. Lights; 9. Recover; 10. Nears; 11. Fuse; 12. Astride; 13. Say; 14. Spot; 16. Rigs; 18. Gas; 20. Readier; 21. NASA; 24. Going; 25. Iridium; 26. Cohere; 27. Shear.
DOWN: 1. Purify; 2. Locks; 3. Rove; 5. Igniters; 6. Heating; 7. System; 8. Array; 13. Stringer; 15. Planish; 17. Tragic; 18. Grain; 19. Hammer; 22. Amide; 23. Hiss.

NRO Declassified and Reorganised

Sir, The National Reconnaissance Office was created on 25 August 1960 to manage the United States' satellite intelligence programmes. It is a joint CIA/Air Force/Navy office that did not officially exist until it was declassified in September 1992. Its current budget, although classified, is estimated by outside observers at round $7 billion. The NRO, by providing the CIA and the Defense Department with timely intelligence on the military capabilities of the Soviet Union, deserves a great deal of credit for helping to win the Cold War.

For the first time, the NRO's former organisational structure has been revealed*. It was stated that the NRO prior to the early 90s consisted of three "Programs", known as A, B and C. A was the Air Force, B the CIA and C the Navy program. These three managed the various reconnaissance and signals intelligence programmes for which the NRO was responsible.

In July 1989, the Secretary of Defense and Director of Central Intelligence (DCI) stated their intention to designate the CIA's Director of Development and Engineering as the Director of Program B, providing a full-time manager for that Program. This apparently formalised a pre-existing situation since this person was apparently already responsible for the day-to-day operation of Program B despite the fact that it was apparently officially headed by the CIA's Deputy Director of Science & Technology. Other changes included the formation of a Joint Senior Advisory Board to Advise the NRO Director and the SecDef and DCI on NRO issues.

Beginning in 1989, the congressional oversight committees began pushing for an overhaul of the agency. One of the suggestions was that various NRO facilities spread throughout the United States and heavily based in California, be collocated at a common site. This led to the planning of a headquarters facility in Virginia. The then Secretary of Defense Dick Cheney and Director of Central Intelligence William Webster both opposed further restructuring of the organisation recommended by the committees, such as giving each Program Office responsibility for a specific mission area, and apparently advocated the changes listed above. The Congress recommended that a major outside study be undertaken as to the future role of the NRO to be headed by retired president and chief operating officer of Lockheed Corporation Robert Fuhrman and completed in 1992. The study recommended that the organisational structure be changed. It was apparently to be reduced to two Programs - imagery and sigint, with the Navy incorporated into the latter. The Fuhrman study also recommended that even further collocation take place, with many of NRO's technical contractors and separate Program Offices being moved to the same site as its headquarters facility. This prompted an expansion of the site from two to four buildings. Each building has six stories, with one underground in order to meet height restrictions near the airport. As one would expect, extensive security and computer facilities have been incorporated into the facility, as have a cafeteria, conference centre and other work-related amenities.

Another of the new revelations to emerge from the hearings was the NRO's seal, reprinted here. This seal was developed after the decision was made to declassify the organisation in 1992. It was approved by former NRO Director Martin Faga in February or March 1993 and registered with the Institute of Heraldry. It is not clear if there was another, classified, NRO seal before this one.

DWAYNE A. DAY
Space Policy Institute
Washington DC

*During recent hearings held by the Senate Select Committee on Intelligence on 10 August and the House Permanent Select Committee on Intelligence the following day, new insights were revealed as to the structure of the NRO. The unusual open hearings were called to discuss the NRO's new headquarters facility near Dulles International Airport in Virginia, approximately 40 km from Washington.

NRO's recent seal.

Gemini EVA

Sir, With reference to the letter by Gary L. Harris (***Spaceflight***, October 1994, p.353) and the rescue capability of the Voskhod spacecraft, it is worth recalling that the American Gemini craft was no better in this respect. Mike Collins in *Carrying the Fire* quite clearly states that in the event of the astronaut on EVA becoming incapacitated, there was no alternative but to abandon him.

This was due to the rigidity of the early suits as mentioned in Gary Harris' letter.

E.T. PUGH
Essex, UK

Kennedy: A Reassessment

Sir, Truly I wish to congratulate Dr David Baker about the Reassessment - one of the most rightly deserved in history - of JFK (***Spaceflight***, October 1994, p.347) and on readjusting "King" Arthur on a Gump pedestal, NOT a visionary one.

NICO SCHIERANO
Pinerolo, Italy

Animals in Space

Sir, With reference to the correspondence concerning Felix the French Space cat (***Spaceflight***, June 1994, p.197), there is an issue of ***Spaceflight*** (September 1964, p.151) which has a photograph of Felix and identifies the flight date as 18 October 1963.

This corresponds to the entry in "Astronautics and Aeronautics, 1963" (NASA SP-4004) which reports for 18 October 1963 - "France successfully launched a cat into space onboard a Veronique rocket and brought it to a safe landing".

The "History of Rocketry and Astronautics - Volume 8" has a history of the Veronique rocket. In the tables of launches the 18 October launch in 1963 is identified as being a Lyman Alpha experiment on Veronique AGI 47 and that the vehicle was "destroyed for safety at 27 seconds". This same article identifies "Animal behaviour" Veronique launches as having taken place on:

- 22/02/61 Veronique AGI 24 [S], Rat successfully recovered.
- 15/10/62 Veronique AGI 37 [S].
- 18/10/62 Veronique AGI 38 [S] - note this coresponds to the quoted date of the Felix flight but a year earlier.
- 24/10/63 Veronique AGI 50 [F], "Failure (separation pad-rocket)".

After the first launch, the three remaining launches involved two launches with mice and one apparently successful launch with a cat. I have had difficulty definitively correlating the mice and cat launches to specific launches.

CARL W. RIGG
California, USA

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

– Society News

Technical Symposium

Space Industrialisation as a Response to Global Threats

On the 23rd June the BIS held its first symposium on the subject of "Space Industrialisation as a Response to Global Threats" at the Society's headquarters. The meeting opened with an invited paper from Dr A.R.Martin of AEA Technology at Culham.

It was a paper by Tony Martin at the BIS Space '84 conference* that started much of the UK work looking at astronautics and global threats so it was appropriate for him to highlight the modelling work throughout the world that followed on from that paper. He concluded that there were four uncertainties that prevented development of space industry in the way that these models suggest was needed:

1. Have we the correct models? That is, are the modelling techniques being used answering the real questions of concern and providing a good basis for decision making? The answer is a qualified yes.
2. Have we enough time? The original work highlighted a finite window of opportunity when a breakout into space can occur. That window seems to either have closed or be starting to close.
3. Have we the will to succeed? Of the necessary infrastructure goals only the space station is funded and even that has an uncertain future.
4. Have we the correct approach? Is advocating large ambitious projects like the Japanese proposal for seven Solar Power Satellites a year by 2000 a realistic response to the issue? Or should the short term planning concentrate on less ambitious, more incremental, improvements?

In view of the lack of time and the lack of real progress Dr. Martin's was a basically pessimistic view. A theme to some extent reflected in two subsequent papers by Mark Hempsell and John Pearsall.

Mark Hempsell of the University of Bristol presented a review paper on the history of thinking on the use of space industrialisation as a means of overcoming limits to growth. Starting with Tsiolkovski who first discussed the argument in 1911, the paper outlined the development of written work on the subject up to the recent British work. The paper pointed out that despite the long history of internal debate there has been no influence outside the space community. A partial explanation for this was suggested by John Pearsall who reviewed the effectiveness of using limits to growth as an argument for space investment and considered that in a real political context it is unlikely to have much of an impact.

*Tony Martin's 1984 paper examined the impact of space industrialisation on the global dynamic models used by Neo-Malthusian to warn of limitations to economic growth and he showed that space industrialisation provided a way of breaking out from these limitations.

SPACELINE: A Society space news service to the general public in the UK.

Dr Anders Hansson's paper also considered the political perspective starting with a new role defined for government from Japanese thinking which is to provide "peace of mind" in a national or even global sense. The paper considered current problems with major capital intensive industries and compared some of the longer term resolutions of these problems that these industries propose with the use of space industrialisation.

Marco Bernasconi from the OURS Foundation in Switzerland reported the results of an analysis of the change in land surface characteristics and other thermal impacts due to different energy generation options showing that even many green favourites like solar energy introduce changes in thermal flux at levels that are already known to affect global weather. Although even extraterrestrial energy sources have some impact this is much reduced over terrestrial sources and the paper argued that this is a further reason for the consideration of space power options.

Two papers addressed technical questions. David Ashford of Bristol Spaceplanes Ltd reviewed the use of sub-orbital aerospaceplanes not only as a development of orbital systems but as commercial systems offering sub-orbital flights as a way of starting the space industrialisation process.

Alan Bond of Reaction Engines Ltd. looked to the longer term and outlined a method of returning large quantities of material (particularly metals) from the Moon to the Earth. Large metal disks are launched by electromagnetic accelerators towards the Earth. On reaching the Earth's atmosphere the shape provides for a stable unguided re-entry with a heat loading that is capable of being absorbed by the disk. The disk then makes a hard impact with the ground at a designated recovery site. Intriguingly the energy to deliver the material is only 5% of that needed to refine it and the lunar source would be capable of supplying all the world's metal requirements.

MARK HEMPSELL

More Work Needed on Space Concepts to Shape the Future of Mankind

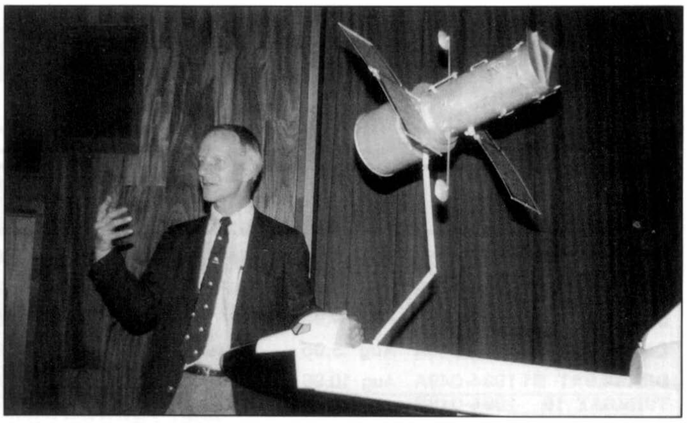
After the Society's 60th Anniversary in October 1993, it was decided that a look forward to the next 60 years would provide a fitting complement to the Society's history over the preceding 60 years. Hence was born the Project ***Vision 60* Plus**.

Dramatic and important developments have been the achievement of space exploration over the last 60 years. To ensure that the same can be said of the next 60 years, new concepts need to be identified, evaluated and promoted. For details of ***Vision 60* Plus** see *Society Announcements* on the inside back cover.

Hubble Space Telescope Mission

Claude Nicollier Addresses the Society

Mark Hempsell (Chairman) introduced ESA astronaut Claude Nicollier, a Fellow of the Society, to the special meeting arranged at the Scientific Societies Lecture Theatre on 24 September and attended by some 70 members and their guests. Claude, who had earlier flown on Shuttle flight STS-46 in 1992 which saw the release of the Eureka Satellite, was now to describe his involvement in the repair of the Hubble Space Telescope during mission STS-61 in December 1993. His role in both Shuttle flights had been the operation of the Remote Manipulator System (RMS).



Above: **Claude Nicollier points out various aspects of the mission in this photo supplied by Dr Neil Da Costa, who writes saying: "I really enjoyed meeting Claude Nicollier and listening to his presentation".**

Claude began with a handsome acknowledgement to the European contribution to the success of the STS-61 Mission by pointing out that this had been made entirely by the UK, in particular by British Aerospace, and adding that, as extremely good coverage of the Hubble Space Telescope Servicing Mission had already appeared in ***Spaceflight***, he proposed to give a personal account of the Mission, the first part concerning the preparation, the second in the form of a film and commentary dealing with the flight itself and the third with the enhanced pictures returned from HST after repair.

Approach to the HST took place over the Indian Ocean, success depending on a one-off spot-on retrieval as there was insufficient propellant in the Shuttle to enable additional attempts to be made. The distortion of the solar array became clearly visible on approach, the subsequent recovery by the Arm being celebrated onboard with the consumption of a Swiss chocolate bar fashioned in the shape of a miniature HST.

The full repair was carried out expeditiously, thus allowing some time for other observations. Film captured lightning flashes from a thunderstorm over the Gulf of Mexico and also the path of a meteorite flashing through the Earth's atmosphere far below. Particularly intriguing was a series of night-time pictures of the Earth, taken on return and beginning with the lights of Paris, moving over Sicily, Alexandria in Egypt and so on. Sunrise took place in about 15 seconds.

He described the Mission as spectacular from start to finish, even though it began as a mixture of anticipation, joy and fear.

Responding to a question he added that the Shuttle Programme is now mature and has produced a very reliable vehicle. About the future of Europeans in space, Claude conceded that, with the wings of Hermes clipped, the only foreseeable flights were those with the Shuttle and Mir. Europe lagged far behind in manned space flight and, sadly, he did not see a very bright future for Europeans in space over the next decade or so.

Added interest to the meeting was provided by a special display put on by British Aerospace. This included a large model of the Shuttle with the HST poised above it on the Arm, thus providing members with cameras some very suitable souvenir shots with Claude pointing to various aspects of the Mission.

LEN CARTER

George Spiteri, FBIS writes:

Claude Nicollier gave a fascinating talk to members of the BIS. I also had the opportunity to put several questions to him both before and after his presentation. He said the flight was proceeding so well that the crew expected a problem after each successful EVA and it was a credit to their training that things went so well.

He recalled being surprised on first seeing one of the solar arrays warped and regarded it as a pity it could not be returned to Earth for analysis.

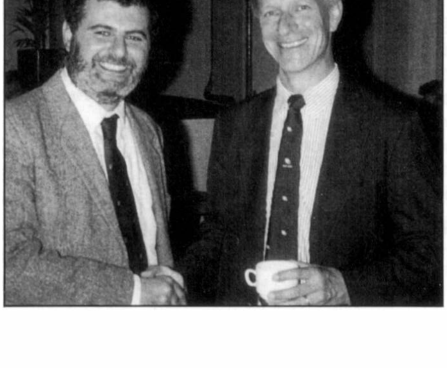
He could not single out any particular highlight of the flight; the whole mission was tremendous from launch to landing, although his night-time take-off and landing were more spectacular than the daytime ones on his first flight in 1992.

The lasting impressions however were the spectacular views of Madagascar and the Chilean and Australian coasts, saying that going into space is a "great way to learn geography".

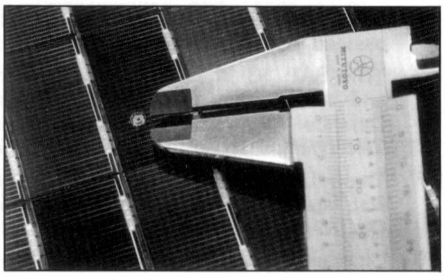
Finally he expects to fly again, probably on the Tethered Satellite System (TSS) 2 mission that includes old crewmates Franklin Chang-Diaz and Jeff Hoffman.

My thanks to Len Carter and Ms Shirley Jones; it certainly was a memorable day.

George Spiteri (left) with Claude Nicollier.



Hubble Array Impacts



A typical micrometeorite impact in the Hubble array that the STS-61 crew returned from orbit. The whole double panel contains almost 25,000 cells, 672 impacts with a diameter of 1.2mm or more have been counted. **BAe**

Earlier this year, British Aerospace invited inspection of the old Hubble array. The initial impression was that it still looked like new, apart from discolouration of the orange substrate on which the cells were mounted. On looking closer the occasional impact hole could be seen on the cells due to micrometeoroid impact. British Aerospace's preliminary visual inspection indicated that the whole wing suffered between 5000 and 6000 impacts in its four year life. The effect of these range from slight grazing to complete puncture of the cells and blankets. Mike Newns, British Aerospace project manager, said that the preliminary testing showed no degradation in the arrays electrical performance from the tests made before launch despite the impacts and exposure to radiation.

MARK HEMPSELL

SATELLITE DIGEST-270

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Cosmos 2285	1994-045A	Aug 2.83	Plesetsk	Cosmos	825 ?	Aug 2.89	74.03	104.98	974	1,013	[1]
APEX (P90-6)	1994-046A	Aug 3.61	EAFB	B-52/Pegasus	261	Aug 5.20	69.97	114.95	363	2,544	[2]
DBS 2	1994-047A	Aug 4.00	ER	Atlas-2A	2,860	Aug 12.98	0.04	1,436.50	35,775	35,813	[3]
Cosmos 2286	1994-048A	Aug 5.05	Plesetsk	Molniya	1,900 ?	Aug 8.55	62.89	717.40	569	39,767	[4]
BRASILSAT B1	1994-049A	Aug 10.96	Kourou	Ariane 44LP	1,765	Aug 20.00	0.44	1,436.06	35,723	35,849	[5]
TURKSAT 1B	1994-049B				1,779	Aug 21.67	0.09	1,431.67	35,619	35,781	[6]
Cosmos 2287	1994-050A	Aug 11.64	Tyuratam	Proton-4	1,300 ?	Aug 27.02	64.88	675.46	19,112	19,134	[7]
Cosmos 2288	1994-050B				1,300 ?	Aug 28.67	64.82	675.81	19,013	19,171	
Cosmos 2289	1994-050C				1,300 ?	Aug 22.45	64.84	675.58	19,113	19,139	
Molniya-3 46	1994-051A	Aug 23.61	Plesetsk	Molniya-M	1,750 ?	Sep 1.99	62.79	717.90	605	39,756	[8]
Progress-M 24	1994-052A	Aug 25.60	Tyuratam	Soyuz	7,250 ?	Aug 30.80	51.65	92.48	394	398	[9]
Cosmos 2290	1994-053A	Aug 26.50	Tyuratam	Zenit-2	13,000 ?	Aug 26.56	64.81	89.55	212	293	[10]
USA 105	1994-054A	Aug 27.37	ER	Titan-4/Centaur	4,500 ?	No orbital data released					[11]
Optus-B 3	1994-055A	Aug 27.97	Xi Chang	CZ-2E	1,700 ?	Sep 6.02	0.87	1,474.96	36,666	37,422	[12]
Kiku 6	1994-056A	Aug 28.33	Tanegashima	H-2	3,800 ?	Aug 31.69	13.08	845.96	7,796	38,707	[13]
DMSP-2 7	1994-057A	Aug 29.74	WR	Atlas-E	823	Aug 29.78	98.92	101.95	843	859	[14]

NOTES

1. Purpose unknown - orbit similar to early navigation satellites.
2. Advanced Photovoltaic and Electronics Experiment (APEX) launched to determine long-term effect of harsh radiation and plasma environments.
3. DBS 2 (Direct Broadcast Service) is a communications satellite, using a Hughes HS-601 satellite bus. Satellite deployed over 258-259 °E and carries a SpaceArc time capsule.
4. Oko early warning satellite.
5. BRASILSAT B1 is a telecommunications satellite, built by Hughes Space and Communications for Embratel in Rio de Janeiro, Brazil. Satellite initially located over 299 °E, but the planned operational location is 290 °E.
6. TURKSAT 1B is launched for telecommunications, television and data transmissions, built by Aerospatiale Espace and Defence for the Turkish Ministry of Post and Telecommunications. To be deployed over 42 °E.
7. Three Uragan satellites in the GLONASS navigation series: first launch to use the third orbital plane scheduled for the GLONASS system.
8. Communications satellite.
9. Unmanned cargo freighter, carrying supplies to the cosmonauts aboard the Mir Complex. Planned docking for August 27 was aborted when the spacecraft was 150 metres from the Mir Complex: a second docking on August 30 also failed. A third docking on September 2, controlled manually by cosmonaut Malenchenko from inside the Soyuz-TM 19 spacecraft, was successful.
10. First use of Zenit launch vehicle to place a probable photoreconnaissance satellite into orbit.
11. No details of this classified Department of Defense launch. Payload might be an ELINT satellite.
12. Third launch of Australian Optus-B satellite by the Chinese. Payload is a Hughes HS-601 bus: satellite owned by Optus Communications Pty. To be located over 156 °E.
13. Kiku 6 (also called ETS 6, Engineering Test Satellite, before launch) was planned to demonstrate the technology base for a large-scale domestically built geosynchronous orbit satellite, development of advanced satellite communications and technologies and the more general development of the satellite's equipment in orbit. Failure of apogee kick motor prevented planned placement into geosynchronous orbit over 153.8 °E and the mission had to be abandoned.
14. Block 5D-2 Defense Meteorological Satellite Program satellite. Satellite bus based upon Martin Marietta (originally GE) Astro Space's NOAA TIROS bus.

ADDITIONS AND UPDATES

1976-073A Comstar-D 2 is still drifting after being boosted off-station in February and has probably been retired. Add the following retirement orbital data: 1994 Feb 25.25, 8.78°, 1,440.28 minutes, 35,857 km, 35,880 km.

1981-096A SBS 2 has been drifting since being manoeuvred off-station in January and is probably retired. Add the following orbital data: 1994 Feb 7.18, 5.31°, 1,435.24 minutes, 35,758 km, 35,782 km.

1983-065A Galaxy 1 has continued drifting after being manoeuvred off-station in March and has been retired. Add the following retirement orbital data: 1994 Mar 26.24, 0.21°, 1,438.27 minutes, 35,808 km, 35,850 km.

1983-098A Galaxy 2 was manoeuvred off-station over 285 °E in mid-May. Since it was still drifting at the end of July it has probably been retired. Add the following retirement orbital data: 1994 May 21.63, 0.21°, 1,437.75 minutes, 35,816 km, 35,822 km.

1985-025A Orbital data issued for INTELSAT 501 at the end of July indicated that the satellite has been re-located over 64 °E.

1985-048B Morelos 1 was still drifting at the beginning of August and has probably been retired after being boosted off-station in March. Add the following retirement orbital data:- 1994 Mar 19.49, 0.12°, 1,447.66 minutes, 36,011 km, 36,014 km.

1987-078B According to the Two-Line Orbital Elements, EUTELSAT-1 F4 was tracked over 25 °E at the end of June, but by mid-July the satellite had been re-located to 30 °E.

1988-063B According to the Two-Line Orbital Elements, EUTELSAT-1 F5 was tracked over 21 °E in mid-May, but by mid-July the satellite had been re-located to 23-24 °E.

1988-091B TDRS 3 was re-located over 188 °E during July 27-29.

1991-015A According to the Two-Line Orbital Elements, Astra 1B was tracked over 23 °E on May 21, but by Jun 2 the satellite had been relocated to 19 °E.

1992-041B According to the Two-Line Orbital Elements, EUTELSAT-2 F4 was tracked over 4 °E on Apr 10, but by Jul 8 the satellite had been re-located to 8 °E.

1994-039A The launch date/time for Columbia (STS-65) should be 1994 Jul 8.70 and the landing date/time should be 1994 Jul 23.44.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight/JBIS*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

2 November 1994 — 7 - 8.30 pm

Chinese Space Programme

Phillip Clark,
Molniya Space Consultancy

A review of the programme's history, a look at its current status and an attempt to predict in which directions we can reasonably expect the programme to continue.

7 December 1994 — 7 - 8.30 pm

Collision of Comet Shoemaker-Levy 9 with Jupiter

Prof. I.P. Williams,
Queen Mary and Westfield College, University of London

The comet impact with Jupiter provided the world with a spectacular event, images of which were reproduced widely on Television and the Press. The talk will show many of the images and give an overview of new results relating to the dynamics of orbits, the structure of SL9, the composition of SL9, the atmosphere of Jupiter and the structure of the planet.

1 February 1995 — 7 - 8.30 pm

Great Balls of Ice - The Satellites of the Outer Planets

Dr David A. Rothery,
The Open University

The giant planets have considerable families of satellites, all icy except Io. Counting Pluto and Charon, there are 18 icy bodies large enough to have assumed spherical shapes (>200 km radius). Although their outer regions are icy, the processes that occur upon and within them mimic the geological processes, such as volcanism and tectonics, with which we are familiar on terrestrial planets.

Call for Papers for a Special Issue of JBIS

The pioneering role of the Society during its first 60 years of existence provided many new space concepts that significantly influenced subsequent astronautical developments.

The Society is now set to continue in this traditional pioneering role and, on the recommendation of its Advisory Committee on Science and Technology, the Council has adopted a project of wide interest and appeal. It has the theme title:

***Vision 60* Plus**

and its aim is to identify and review anticipated space developments over the next 60 years or more that will significantly affect the course of human progress and thought.

Preliminary guidelines have been established that offer the widest scope for contributions from the sciences, technology and sociology on a world-wide basis. Contributors can expect support from the review and presentation procedures offered by the Society's programme of publications and meetings.

*To be a participant in **Vision 60** Plus please notify the Executive Secretary of your interest and receive a copy of the Guidelines.*

The first steps of ***Vision 60* Plus** are already underway with the preparation of a special issue of ***JBIS*** for which a number of papers are in preparation and for which a **Call for Papers** is now being made.

Intending contributors to the ***Vision 60* Plus** issue of ***JBIS*** should send details as soon as possible to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England.

5 April 1995 — 7 - 8.30 pm

Alternative Space Launch Concepts

Colin Jack,
Oxford Mathematical Designs

Launching orbital payloads by rocket costs upwards of £4,000/kg. Many potentially cheaper ways have been suggested, ranging from the plausible to the fantastic. But how to tell which is which? Can we rely on the judgement of the big space agencies? Colin Jack will be discussing the proposals, and trying to pick some winners. Suggestions from the floor will be welcome!

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

SYMPOSIUM

3 June 1995 — 10 - 4.30 pm

Soviet Astronautics

This annual event, now in its fourteenth year, will review the programmes run by the Soviet Union and its successors such as Russia, Ukraine and Kazakhstan. The programme is expected to include the latest information on cooperation with the United States, a cosmonaut update and an historical review of an unmanned programme.

Authors wishing to present papers should contact the Executive Secretary.

Advance Registration is necessary.

Registration: Forms are available from the Executive Secretary. Please enclose a sae.

JBIS

The November 1994 issue of the Journal of the British Interplanetary Society is now available and contains the following papers :

Space Missions and Astrodynamics (Part II)

Solar Sailing for Radio Astronomy and SETI: An Extrasolar Mission to 550AU

•

Engineering Features of Interplanetary Missions which Previse the Extraplanetary Missions

•

Wide Band and Multifrequency Feed Systems for Orbiting Radio Telescopes

•

Stability and Control Problems in Earth-Moon Lagrangian Point L2

•

The Hipparcos Astrometric Satellite and Visual Double Stars

•

Recent Developments about Space Missions to the Solar Foci

Copies of JBIS, priced at £17.50 (US$32.00) to non-members, £5.00 (US$9.00) to members, post included, can be obtained from the address below. Back issues are also available.

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SPACE '93 Satellite Link-Up

A fascinating, informative chat by Arthur C. Clarke, describing his work - past, present and future, as he responds to questions put by BIS members at the Society's 60th Anniversary Meeting on 17 October 1993.

The question and answer session is led by astronomer and "Sky at Night" TV personality Patrick Moore and by lunar astronaut Buzz Aldrin. A lasting and entertaining record of a unique occasion.

The video pictures are exclusively of Arthur C. Clarke, with audio presentations by other participants. *50 mins*

STS-46: Mission Highlights

This features the 12th flight of Atlantis with a crew of seven. Flight objectives included the deployment of the European Recoverable Satellite (Eureca) using the Robot Arm operated by Mission Specialist Claude Nicollier and the first, though unsuccessful, launch of a Tethered Satellite. *50 mins*

STS-54: Mission Highlights

The flight of Endeavour with a crew of five features splendid scenes of the launch of theTracking and Data Relay Satellite (TDRS) against an Earth backdrop and experiments with Biopack. Onboard crew activities include a variety of physical exercises. The video concludes with spectacular EVA and Earth shots. *50 mins*

STS-49 Mission Highlights

The details of this flight by the Shuttle Endeavour, 7-16 May, 1992, are well covered, e.g. the preliminaries of suiting-up, the White Room, entry to orbiter, removal of gantry, count-down, engines start, lift-off, and detailed operations during the flight. A principal aim was to retrieve the Intelsat VI satellite which had previously failed to reach synchronous orbit. Though more difficult than expected, it was achieved and sent on its way. A second aim was to practice basic space station assembly work by Extra-Vehicular Activity (EVA). This was also very successful. The video concludes with an interesting press interview with the crew. *1hr 50 mins*

Giotto - Encounter With Halley

This ESA video covers the history of the famous comet from its earliest sightings to ESA's Giotto mission that flew within 600 km of the icy body in 1986. *56 mins*

Ulysses, The Movie

In this ESA video, superb computer graphics describe the mission of the ESA/NASA solar polar probe launched by the Space Shuttle in October 1990. *26 mins*

A Collection of "The Movies": LA, Earth, Mars & Miranda plus Voyager 2 Neptune Encounter

Created by the Jet Propulsion Laboratory, this video, features four short productions which use satellite/space probe images and supercomputer graphic animation. *17.5 mins*

An extra feature, 'Voyager 2 Neptune Enconter', illustrates the various aspects of Voyager's encounter with Neptune. *29 mins*

Space Shuttle Challenger: Accident & Investigation

On January 28, 1986, the Space Shuttle Challenger exploded 73 seconds after blast-off from the Kennedy Space Center. All seven crew members died. This video documents task force activities and findings and provides a concise, technical explanation of the cause of the Challenger accident. *29 mins*

STS-26: The Retuirn to Flight

This video depicts the highlights of the STS-26 mission, the first launch since the Challenger accident. During the flight, the five-man crew deployed a Tracking and Data Relay Satellite. There is no commentary on STS-26 Highlights, apart from the astronauts' transmissions. The tape is accompanied by a FREE mission guide. *57 mins*

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Spaceflight

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STS-64 Mission Report

Features

News & Events

Space Miscellany

Front Cover: **The first in-space rehearsal on 16 September 1994 during mission STS-64 of a contingency rescue using the new SAFER (Simplified Aid for EVA Rescue) system. Carl J. Meade wears the small backpack with its chest-mounted control unit while Mark C. Lee remains anchored to the Shuttle's Remote Manipulator System.** **NASA**

The Congress logo displayed above the welcome sign. Th.P./SIC

BY THEO PIRARD, FBIS
Belgium

The 45th IAF Congress, Jerusalem

9-14 October 1994

Annual Space Summit Highlights Astronautics for the 21st Century

It is a long time since NASA and the USSR were competing at an IAF Congress to present the latest exploits of space shuttle astronauts and cosmonauts aboard the space station. At this event no accounts of the spectacular repair of the Hubble Space Telescope nor of the most recent American or Russian EVAs were given. Manned space flight is no more the driving force behind new activities and advanced technologies in space. The International Space Station did not receive much interest and neither NASA nor RKA described in detail the phases and uses of this important and expensive piece of infrastructure to be placed into orbit.

Astronautics at a turning point

Attendance at the Congress was lower than expected which questions the appropriateness of organising such an important event about astronautics every year, while research and development efforts are going down. Only 810 people registered instead of the 1,500 of previous years. Many papers and lectures were cancelled at the last minute because of financial restrictions from agencies and the psychological effects due to the atmosphere of terrorism.

Nevertheless the Congress offered a useful opportunity to evaluate the new route that astronautics is following in its progress towards the next century; and, as a result of the strong participation of the home country, to understand in what ways Israel will be contributing to the development of space technology and applications.

Five inter-related trends could be seen to be evolving:

1. *Low-cost access* to space with the development of new and modular launch vehicles.
2. *Small is beautiful* with the use of miniaturised systems and standardised micro- and mini-satellites for Earth applications and interplanetary exploration.
3. *Single-stage-to-orbit* as a favoured concept for new space transportation systems.
4. *International cooperation* to avoid duplication of effort and to coordinate ambitious programmes in space science and technology.
5. *Public information* to inform people, especially young people, about the challenges and progress in space.

Two countries presented a number of interesting papers: the Ukraine and China. The record for industrial presentations was held by the French company Aerospatiale which presented some 15 papers as well as exhibiting their space products.

Aerospatiale was particularly in evidence at the Congress with an attractive stand showing models of Ariane 5 and Ariane 6. Th.P/SIC

Low-Cost Access

The objective of this activity is to reduce the cost of access to space from some $15,000 to some $2,200 per kg in LEO.

ESA engineer, Walter G. Naumann, presented a global overview of small launch vehicles of the future. Six small launchers are at present operational:

In USA, Pegasus (Orbital Sciences Corp), Taurus (Orbital Sciences Corp); in Russia, Cosmos (PO Polyot), Start-1 (NII Teploviy Tekhnologiy); in Japan, M-3S-II (ISAS); and in India, ASLV (ISRO).

Under development are some 15 launch systems - most of them using solid motors:

In USA, Aquila (AmRoc), Conestoga (EER), LLV (Lockheed Missiles & Space), PA-2 (PacAstro); in Western Europe, Capricornio (INTA, Spain); in Russia, Rokot (KB Salyut), Shtil, Volna and Vysota (KB Mashinostroenya); in Brazil, VLS (Centro Technico Aerospacial); in Israel, Next (Israel Aircraft Industries); in China, Long March 1D (China AeroSpace Corporation); in Japan, J-I (NASDA) and M-V (ISAS).

Three notable industrial presentations were given:

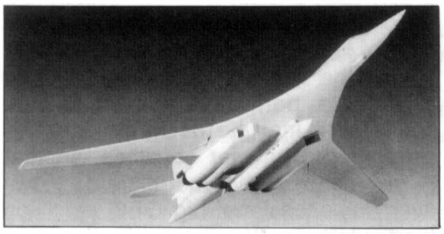
- Lockheed Missiles & Space Company, with United Technologies and Thiokol Corporation, described the family of modular LLV (Lockheed Launch Vehicles) and the performance of their solid motors (Castor 120, Orbus 21). Propulsion represents over 50% of the recurring costs of the LLVs and propulsion cost is therefore a critical factor.
- CNES, with Aerospatiale and SEP, presented the European Small Launcher (ESL) employing solid rocket motors. The three-stage ESL (P50 + P50 + P7) should be capable of placing a one ton satellite into a Sun-

synchronous orbit at 700 km. In the event of a go-ahead decision in 1995, the first flight could take place in 1999.

- DARA, OHB-System and the Russian partners MKB Raduga, Tupolev and OKB MEL are proposing the air-launched space transportation system Diana-Burlak for small satellites and scientific payloads. The system comprises the Tupolev TU-160CK supersonic aircraft as carrier, the two-stage booster with liquid engines and the Iljushin IL-76 command aircraft. The purpose is to launch satellites of 250 to 1100 kg from anywhere in the world at some $4,550 per kg. The first test flight could take place in 1997 with commercial operations in mid-1998.

Small is Beautiful

The use of micro-miniaturised components in space systems is another way to reduce the cost of operations in orbit, of missions in the Solar System, and to allow the advent of new entrants - small laboratories and developing countries - on to the space scene. The future of interplanetary exploration is largely based on the use of micro-systems with light probes. Activities in this area and that of Earth observation technology, which was probably the main focus of the Congress, will be reported in a forthcoming issue of ***Spaceflight***.



Diana-Burlak space transportation system. **OHB SYSTEM**

Single-Stage-To-Orbit (SSTO)

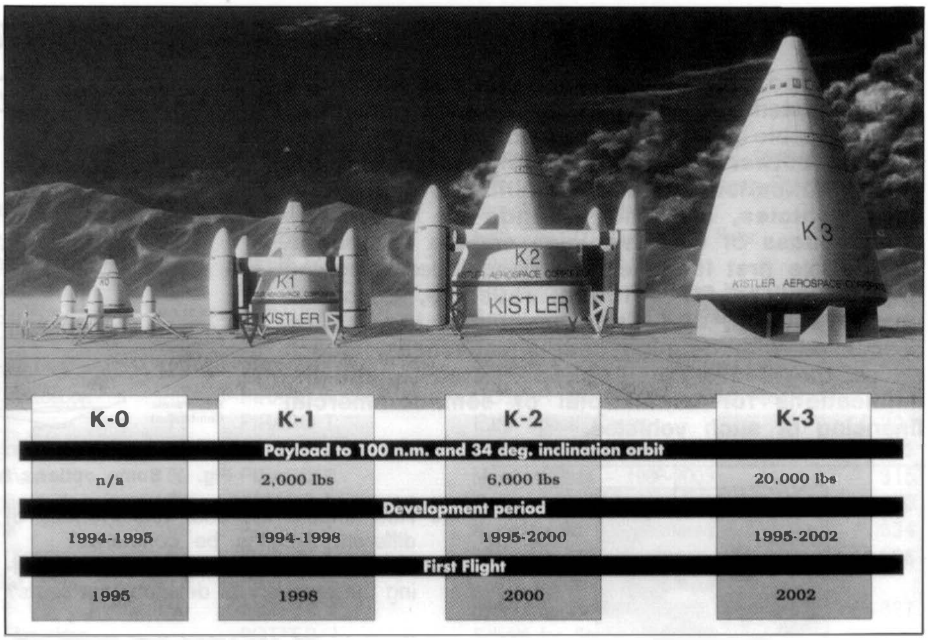
NASA considered that SSTO vehicles are now feasible and practical. Ivan Bekey, NASA Headquarters, stated:

"The SSTO is clearly not the sensitive, difficult-to-build vehicle that past perceptions imply.

"The technologies required for a rocket SSTO exist, but require maturation and demonstration. A focused programme for such maturation and demonstration could be accomplished in 3-5 years, following which they may be confidently utilised for operational SSTO vehicle design and development."

The same views were held by engineers of NASA Langley Research Center and NASA Marshall Space Flight Center:

"NASA has focused the current Reusable Launch Vehicle (RLV) Program on assessing a number of vehicle concepts, maturing the required technologies to an acceptable level and identifying candidate approaches to



The Kistler Rocketship Family. **KAC**

demonstrate the performance and operability of these technologies with a reusable flight vehicle. Providing a space transportation system with low-cost operations is the major overriding requirement for the current RLV Program. A rocket-powered single-stage-to-orbit vehicle has been chosen as the initial goal for the technology and flight demonstration activities."

Two papers on revolutionary space transportation systems were presented:

- By the American businessmen, who in 1993 established the Kistler Aerospace Corporation (Kirkland, Washington) to develop an original but adventurous single-stage-to-orbit system. Kistler Aerospace Corporation is proposing a fleet of K-type SSTO vehicles in a development extending from now to 2002. It is currently working on a K-0 subscale demonstrator to test vertical takeoff, platform separation and vertical landing. This K-0 vehicle, like other K-type vehicles, has a conical shape propelled by one liquid hydrogen-oxygen engine with 3.7 t of thrust. It will take off from a platform which also is powered by four rocket engines (identical to the K-0 vehicle). The test rocket, which will use many of the technologies of the DC-X programme, and its reusable Launch Assist Platform (LAP) are currently being manufactured. First flight is planned in Spring 1995 from White Sands, New Mexico.

The Kistler Aerospace Corporation is looking for funds to go ahead with the next step: the K-1 conical rocket which is intended to go into orbit after taking off from a reusable LAP, which would be rocket-propelled up to an altitude of some 20 km. This LAP is a separate self-contained vehicle with its own guidance, landing rockets and the ability to land at the original launch site on an impressively large net. As described by its promoters, the LAP just moves up and down like an elevator.

The SSTO K-1 vehicle will be 13.5 m high and 10 m in diameter. It will be able to achieve at least 300 missions with a turnaround time of less than a week. This fully reusable rocket will be able to place 900 kg in LEO. First flight can be expected in late 1997 if the Corporation is successful in getting funding of some $500 million. Kistler Aerospace Corporation plans to build a production facility and a Kistler Spaceport at White Sands, New Mexico. It is discussing with the State of Alaska the establishment of a Spaceport at Narrow Cape, on Kodiak Island. The crucial technology of the Kistler project concerns the use and reuse of a vertically-launched platform and the separation from it of the SSTO vehicle, which needs to reach orbital velocity.

- By Japanese engineers of Kawasaki Heavy Industries and of Fuji Heavy Industries, which are largely concerned with the development of the H-II and HOPE vehicles. They presented design criteria for a space tourism vehicle which is being studied in the framework of a research project of the Japanese Rocket Society (JRS). The purpose of this project is to give a new and strong motivation for commercialisation of space transportation through the impetus of tourism. The SSTO vehicle will have the form of a half-egg, a mass of about 550 tons at takeoff, a body height of 22 m and a diameter of 18 m. It will be propelled by 12 cryogenic engines, consisting of 4 booster and 8 sustainer engines, with a conventional bell nozzle, mounted in a circle around the lower tank structure. It is designed to carry up to 50 passengers for one day in orbit. No development schedule was described. ■

Russian-Israeli Cooperation

On 1 September, the space agencies of Israel and Russia signed a Memorandum of Understanding on cooperation in the civilian and commercial uses of space, especially the development of communications satellites.

– Space Transportation
Strategy for a Future Launch System

Many proposals have been made for advanced launch systems to succeed the present generation of expendable rockets for transportation into space. Judging between the various contenders requires the identification of the capabilities required for such vehicles, and the grounds on which the effectiveness of such vehicles can be compared. This article first identifies the capabilities expected to be required for a future, reusable, European launch vehicle, and then discusses the issues associated with defining cost effectiveness, launch prices, the recovery of development costs, and the implications for commercial or semi-commercial financing of such vehicles.

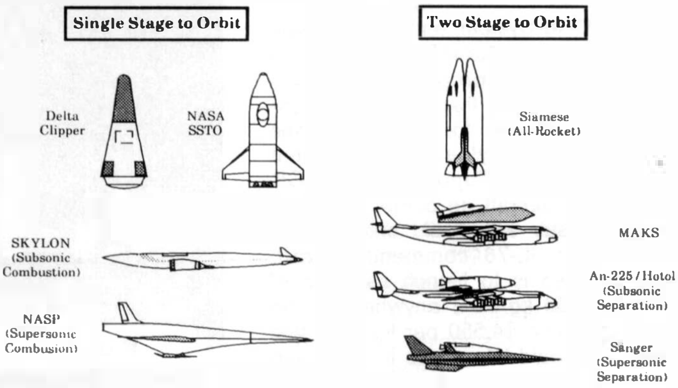


Fig. 1 Some options for reusable launch vehicles.

BY BOB PARKINSON
Matra Marconi Space,
Stevenage, Herts

Introduction

There is now active discussion about the sort of launch system which should be developed to succeed the present generation of (largely) expendable rockets. The US "Access to Space" study [1] identified the development of a reusable SSTO as its favoured approach for the USA at the opening of the 21st Century. Similar discussions are taking place within Europe [2]. Some contenders for possible future launch systems are illustrated in Fig. 1. Clearly, some definition of what is required is needed, and how the different proposals should be judged. The viewpoint taken in this article is a European one, but not uniquely European.

Two possible reasons exist for developing a new launch vehicle. One is that some new capability over current launch vehicles is required - perhaps in lift capability, or to put men into space. The second reason is that a new vehicle would bring cost benefits - allowing cheaper access to space and competitive commercial launch services. Historically, government support seems to have been based on the first of these reasons - from Vanguard and Thor, through Saturn to Shuttle and Ariane. However, there is now some awareness that the second reason may be important to the future well being of space activities.

In defining a future European launch system, three questions need to be answered:

- What capability should such a vehicle have?
- How should the cost effectiveness of different systems be compared?
- What policy should be adopted regarding the recovery of development costs?

It might be expected that "How feasible is a given vehicle" should also appear on this list. But feasibility translates to cost. If there was sufficient investment, then a system like the Starship Enterprise would be possible. But that seems unlikely to be a cost-effective solution to current problems.

The capability required must be defined carefully. Cost-effectiveness in the commercial marketplace is not a secondary issue. In answering "What capability would we like?" there must be caution about adding capabilities which reduce cost effectiveness. The development of one of these systems is going to be expensive. It is unlikely that there are going to be two chances. The requirements specification sets the costs very early, and unless the interactions are understood and acted upon, the resulting system may fail to make spaceflight more economic.

Vehicle Capability

What capability must such a vehicle have?

The simple answer is that the capability must maximize the utilization of the new system. The more a system is used the more cost effective it becomes, as long as it can be used efficiently. Studies at BAe/MMS identified the following missions that need to be considered (Fig. 2). The list is arranged in probable order of priority but all are desirable.

- Launch of existing (and expected) geosynchronous satellites and science missions. Since the new vehicle is likely to launch into low Earth orbit, this will require an additional perigee stage.
- Launch of Earth observation satellites into sun-synchronous polar orbit. Again, it is likely that the satellite itself will require a boost to operating altitudes ~700 km rather than attempting to build a capability for direct insertion.
- Launch of logistic supplies to a Space Station in low Earth orbit. Logistic supplies represent the major component of Space Station operations (and imply some return capability at least). Launching Space Station elements comes rarely and could use other vehicles (not all ESA's satellites are launched by Ariane).
- Transport of human beings to and from the Space Station.
- Support for new initiatives beyond low Earth orbit (eg. the Moon) - since the vehicle lifetime will probably extend well into the next century.

For geosynchronous orbit, a capability of just over 7 tonnes in LEO would launch the existing Eurostar 2200 and a suitable perigee stage. If launch costs fall it may be desirable to make cheaper but heavier satellites, so that 7 tonnes may be insufficient. However, for occasional big GEO satellites (particularly in the Space Station era) it would be possible to launch the perigee stage and the satellite separately and to mate them in orbit. This would allow the launch of satellites up to full Olympus size (3.75 t) with two adjacent 7 tonne launches.

For polar orbits, it is more difficult to say just how big the satellites should be. Large, multi-functional Earth Observation platforms are a product of the launch system used. A small liquid transfer stage of about 1 tonne would be capable of placing Earth Observation satellites of about 3.3 tonnes into 700 km polar orbit. The capability of a new system for such missions could be additionally enhanced by launching the satellite while the vehicle is suborbital (i.e. just after main engine cutoff). The launcher would then make a partial orbit and immediate recovery.

The same liquid transfer stage could launch a 5.7 tonne logistics vehicle to the Space Station. If this logistics vehicle sounds small, it is bigger than the Russian Progress. If Space Station support is required - Europe outside the UK remains interested in this area - then the number of launches per

year rises substantially, typically 6 - 8 launches per year excluding crew [3].

For human transport, flying the crew as cargo in a capsule appears preferable to flying a launch vehicle crew each time. The reliability and abort capability of the system has to be good for economic reasons - see below - and integrating a permanent crew system into the vehicle seems to cost about 2 BAU extra (and adds 2 - 5 tonnes to the launch capability required). A crew capsule can be cheaper.

Finally, there is the question of support for "beyond LEO" activities. In ESA's SYSTEMSI studies [4] a LEO-Moon reusable or semi-reusable transport system using a recoverable OTV with Space Station assembly was identified. By staging at the correct points, a modular Moon Transport System, assembled in Earth orbit, can be devised. The unit element transport size for this is about 8.5 tonnes (which eventually allows elements of this size to be delivered to the lunar surface - most particularly a crew return vehicle).

This last example is the most tenuous case, and not one on which to build the whole requirement. Any system might be expected to "stretch" a little after it entered service. The overall picture arising from current studies indicates that a payload of 8 to 8.5 tonnes in LEO appears reasonable for most applications.

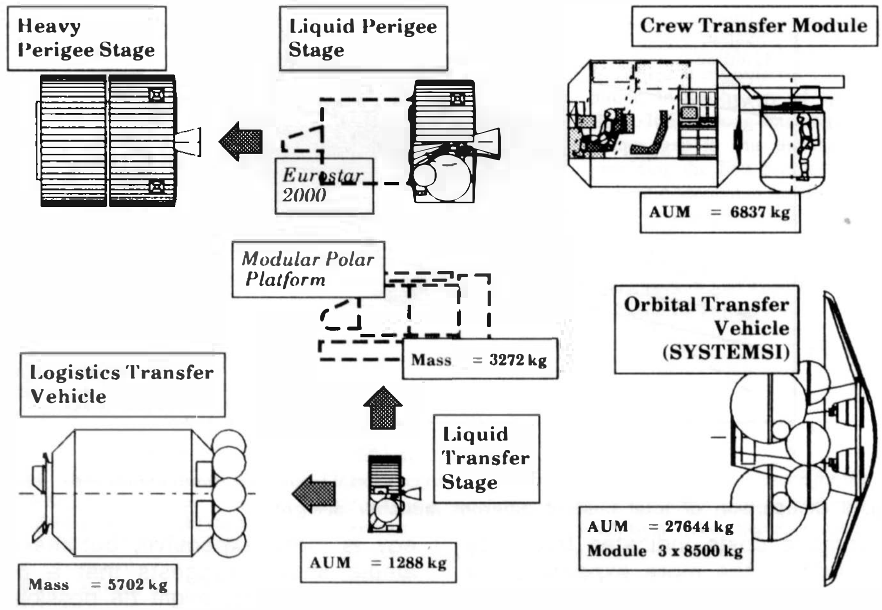


Fig. 2 Some payload/mission studies for a future launch system.

Cost Effectiveness

Recurring Cost Issues

A low flight cost vehicle would clearly encourage new uses for space. Elementary economics teaches that a reduction in the price of a transportation system causes demand to rise faster than cost decreases. But cost effectiveness involves two issues. The first is what should be included in the recurring cost. The second is how the non-recurring costs should be accounted - that is the costs of development and fleet acquisition.

What should be included in recurring cost? This list is taken from the International Academy of Astronautics' Committee on Economics in Space Operations [5]:

- The cost of spares and replacements (and expendable items) needed to keep the system going.
- The cost of the maintenance and support team needed.
- The cost of the flight operations team.
- The cost of maintaining the ground support facilities and equipment.
- The cost of maintaining the support inventory of spares required.
- The cost of propellant (normally fairly small).
- Overhead costs - support crew training, headquarters etc.
- The cost of insuring the risks involved with system aborts and system failures.

Not all of these items are included in current launch vehicle prices. The last line is important for a future system. To calculate the total cost impact on the programme of a vehicle loss or a vehicle abort, the costs of the "get well" programme following a failure, the cost of maintaining the system through the stand down period and so forth are calculated and multiplied by the probability of those events happening (from reliability data) to get the "cost of risk" [6]. Inclusion of this number puts a realistic premium on obtaining a reliable vehicle and almost automatically ensures vehicle survival as a prime aim, making it suitable for human transport. (Since the cost of vehicle loss is typically above 1 BAU, it cannot be allowed to happen too often.)

Having a "confident" abort capability has a number of advantages:

- The vehicle (and payload) are recovered when something goes wrong.
- There is no temptation to press on to destruction when something fails.
- What failed can be established exactly, and fixed.
- Things which did not fail can be used again, avoiding flying with "untested hardware."

Including risk also drives towards reliable configurations. Two stage systems may have better performance and lower sensitivities than single stage systems, but they duplicate the number of systems to go wrong and therefore have lower "inherent reliability."

Non-Recurring Cost Issues

It appears possible to get attractive values for the vehicle recurring cost, but clearly initial non-recurring costs are also important. The Shuttle encountered a number of things which might have contributed to a low recurring cost but which could not be included in the system because the investment cost was too high. To select a vehicle on cost grounds, the non-recurring costs must be included in some way.

The exact way in which non-recurring costs should be accounted depends on the method adopted for financing the vehicle development. A first approximation considers Total Cost alone - the cost of developing the system, purchasing the fleet and infrastructure, and operating it for some number of flights. The number of flights cannot (and should not) be defined with certainty. What may be expected is that Total Cost will increase as utilization increases, but that Total Cost per mission will fall. Typical Total Cost/Utilization relations are shown in Fig. 3. At some utilization, new systems will have a lower Total Cost than old systems (here represented by the expected cost-performance of Ariane 5). If the expected utilization is higher than this critical value, the new system represents a "better buy."

The advantage of this method of comparison is that it is not necessary to know exactly how many flights any system is going to see over a lifetime. Instead, all that is required is an opinion about the minimum number.

Recent work has extended this approach [7]. Fig. 3 assumes that the costs are known with certainty. In reality they are not so well defined. Both vehicle performance and cost estimates will have an associated uncertainty. The lines will not be the thin lines shown but fuzzy bands. If the fuzzy bands overlap, there may not be much to choose between one vehicle and another, or further research may be necessary to improve confidence. Work done so far on uncertainties both in technical performance and in pro-

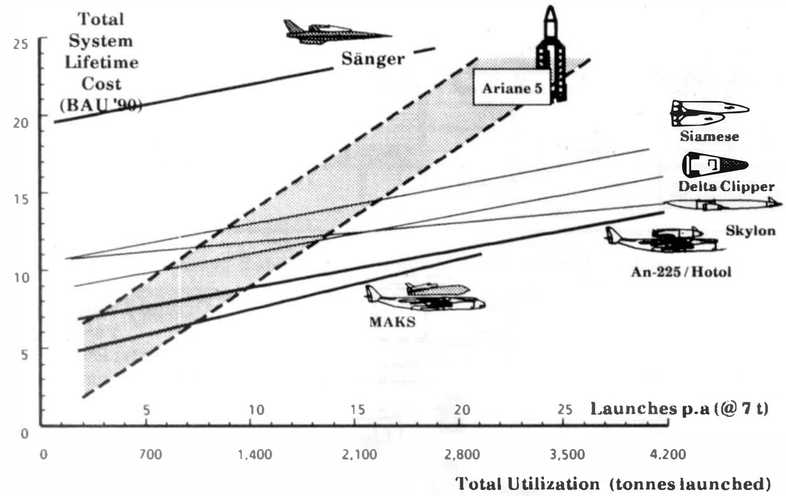


Fig. 3 Comparison of total cost of different launcher designs.

grammatic costs indicates that - by and large - the more expensive the system is the wider the uncertainty band becomes also.

Non-Recurring Cost Recovery

It seems unlikely that it will be possible to continue to develop a new launch vehicle every twenty years indefinitely using government money, and then write off the costs of development as has been done in the past. At some time there will have to be a move towards recovering development costs, or developing new systems as commercial products. The history of the commercial airliner business suggests that this may not be simple, but it is clear that there will have to be a movement in this direction.

The current objection to recovering development costs as part of the launch price is that existing systems prices do not include recovery of development costs, and new systems cannot recover these costs while competing with existing systems. Current launchers such as Atlas and Ariane essentially charge only the recurring costs of hardware and launch operations.

If recurring costs drop dramatically with a new launch vehicle, then it becomes possible to consider recovering non-recurring costs while reducing launch prices.

Fig. 4 illustrates how non-recurring cost amortization might work. The recurring launch cost remains essentially independent of the number of launches (at least to a first approximation). As the number of launches increases, however, the non-recurring contribution to the launch price will fall. Two possible non-recurring recovery strategies are illustrated in Fig. 4. In one the development costs are simply paid off over an extended period (here 20 years of operation). In the second interest is paid on the money owing as if it had been borrowed when the expenses were incurred, and paid back when flights are sold. This latter strategy is more expensive, but the example shown suggests that a cost recovery strategy might be possible if the number of launches lies between 16 and 25 launches per annum. The price ceiling is assumed set by Ariane 5 (projected) prices.

Since the new system will be in competition with existing systems, it is clear that the competitive price "ceiling" is subject to adjustment. If the price per launch remains close to existing charges, the new system may have difficulty in competing as a strictly commercial system against systems "subsidized" in one sense or another. To keep competition "honest" it may still - for the moment - be necessary for governments to "underwrite" the system - at least partially. The fact that development cost recovery is now a significant part of the launch price means that the launch price can be readily adjusted by changing the development cost recovery demands. In addition, governments (through one route or another) will also remain significant users of launch services, so that low marginal costs to government may in itself encourage new uses.

Financing

Simple recovery of the original investment is not the only criterion applied to commercial investment. Long investment times present further problems, and more complex forms of funding are possible. One possibility that has been considered is a mixture of government and private funding during development, and selling the product (an operating launch system) on to commercial "spacelines" (such as Arianespace).

There is an argument that the world would be better off if there were competitive operators of such systems. The manufacturers would be better off, because they would sell more vehicles. The customers ought to be better off because competition tends to keep prices low. And the operators would have to find a smaller share of the development costs. The argument for International collaboration in developing such vehicles is not that the cost is too exorbitant for one country alone (collaboration increases costs!), but that multinational collaboration gives access to a larger market. ESA alone might require no more than four vehicles. Collaboration with Russia and the USA might treble this number.

What needs to be identified is whether effective competition would be possible between operators of different sizes. Since a large part of the launch price would have to go into paying for the initial non-recurring expense (development and an operating fleet), the operator with a larger flight rate would seem to have an advantage. However, an analysis of how much of the launch price remains under the operator's direct control is illustrated in Fig. 5. The conclusion is that, once individual operators' flight rates exceed about 16 per year, a small-but-efficient operator might hope to compete with a big-but-complacent operator.

Development financing schemes involving both government and commercial support have been considered. Commercial participation might be in the form of a "Spaceplane Development Fund" established at the start of the programme by selling shares. Government support might be a constant year by year support through the development period, to be paid back by "royalties" on sales. Initially, interest from the fund rises faster than programme expenditure. With a ten year programme, investors do not start to risk capital until about year 4 - by which time the risk ought to be very much better defined. Later it should be possible to acquire re-investment from the potential operators of the system through "up front" purchases. If sales are made to more than one operator, the costs of development are spread further. Because the government is involved, the commercial investment can be "underwritten" - further encouraging investment.

Such schemes are speculative, and beyond current considerations of how to select the configuration and strategy for a new system. Their importance is to indicate how development costs might be included in the equation. Given the right environment, however, commercial funding could be possible.

This raises the question of "the right environment." With a commercial objective and commercial funding, agency R&D organizations like ESA or NASA may not be the right place to develop a future launch system. Agencies operate under too many constraints - political, organizational and in terms of technology choice. Industry, driven by customer requirements,

may well make better and less costly decisions. And the agencies certainly ought not to operate the final vehicle - they should be its customers [8].

The role of the R&D agencies should be to demonstrate the availability of technology needed to assure a commercial investor that the risk can be quantified. Such assurance may involve flying "demonstrators" as NASA's predecessor NACA did in the late 1940s and 1950s. This is one of the proposals contained within ESA's Future European Space Transportation Investigations Programme - FESTIP. However, perception that a "demonstrator" is required to create the confidence needed to allow a commercial development to proceed will place different requirements on this vehicle from one designed to explore the technology of a new flight regime, for example. In particular, it seems likely that some "pre-selection" of the probable vehicle design will be required, and that this will have to be done not by the agency alone, but in collaboration with possible commercial investors.

In addition, as government agencies, ESA and NASA (and others) may also have to encourage the regulatory environment which makes such investments attractive. Governments will need to make clear the terms under which operators of such future systems will be allowed to fly and to compete for launches, and the manufacturers to make sales of their equipment.

These messages appear to be being heard now, at least in the USA [9]. There will remain a strong political dimension to the problem, however, and it may be a while before any commercial consortium takes the plunge.

Competition is possible

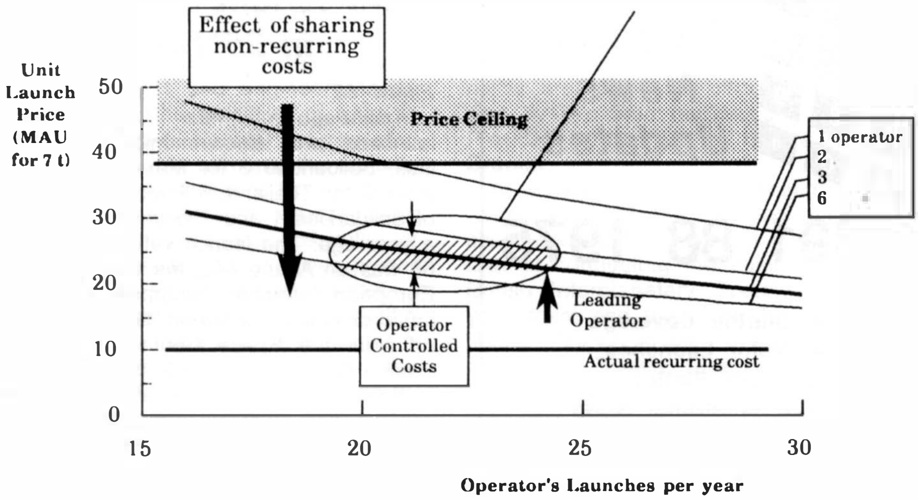


Fig. 5 Possibility of competition between launch system operators.

Conclusions

It is already possible to set some criteria for future launch vehicle selection:

- The vehicle should be modest in size, probably delivering about 8.5 tonnes into low Earth orbit.
- Comparisons between different vehicles should be made on a cost basis for a selected payload size.
- The recurring vehicle flight cost should include the costs of insurance against vehicle loss or mission abort. Abort capability has a strong influence on low recurring flight costs.
- Comparisons between different systems should be made on a Total Cost basis which includes the cost of development and procurement of the initial fleet as well as lifetime operating costs. With such schemes it is possible that at least partial commercial investment could be possible for a future system.
- The role for space agencies such as NASA and ESA is to identify the technology risk and encourage the political environment in which development can take place, and to be a customer for services - not to be a prime developer and operator.

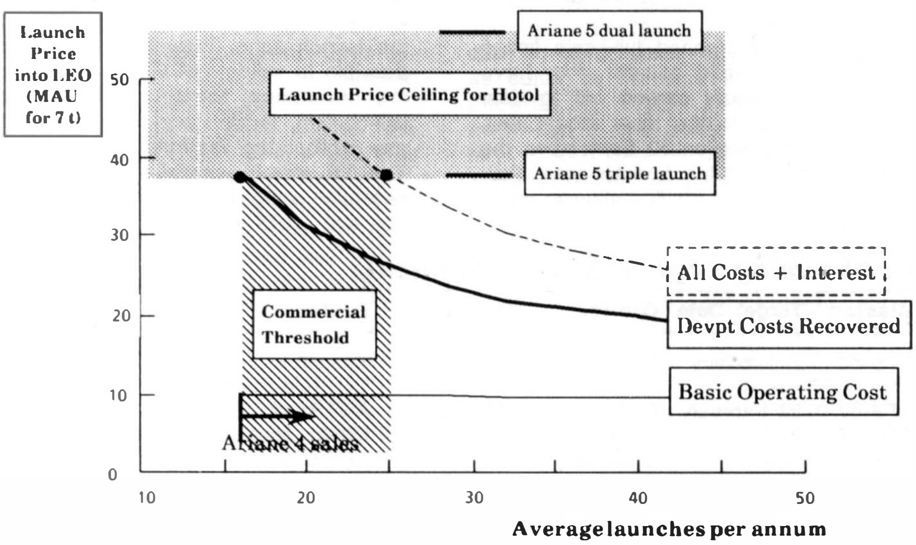
Given these criteria, it is clear that there are a number of possible vehicle configurations which could provide a future system. If these prove close to one another in cost performance then it may not matter too much which one is eventually selected.

It even appears that commercial development of such systems may not be beyond the bounds of possibility, once confidence in the technology has been demonstrated. Universally outside the UK that is seen as a government role. The inability of the UK to invest in the ESA FESTIP programme shows a major lack of understanding in its future strategy for the development of space.

References

1. A.D. Aldrich "Access to Space Study", Summary Report, Office of Space Systems Development, NASA Headquarters, January 1994.
2. H.A. Pfeffer "Actions of ESA to Prepare for Future Space Transportation Systems." European Forum on Space Transportation Systems, Nancy, France, 25-26 November 1993 ESA SP-362 (March 1994), p.81.
3. R. C. Parkinson and C.M. Hempsell "Cost Impacts of Supporting a Future European Space Station", IAA-90-602, 41st International Astronautical Congress, Dresden, Germany, October 1990, *Space Technology*, 12, p.325 (1992).
4. R. C. Parkinson and M.A. Perino, "Sizing a Modest Moon Outpost & Supporting Infrastructure", IAF-93-V.2-612, 44th International Astronautical Congress, Graz, Austria, October 1993.
5. D.E. Koelle, "Launch Cost Assessment of Operational Winged Launch Vehicles", AIAA-92-5021, 4th AIAA International Aerospaceplanes Conference, Orlando, Florida, December 1992.
6. R.C. Parkinson, "Total System Costing of Risk in a Launch Vehicle", IAA-93-6.1-7, 44th International Astronautical Congress, Graz, Austria October 1993.
7. R.C. Parkinson, "Cost Sensitivity as a Selection Issue for Future Economic Space Transportation Systems", IAA-94-IAA.1.1.585, 45th International Astronautical Congress, Jerusalem, Israel, October 1994.
8. J. Bennett and P. Salin, "The Private Solution to the Space Transportation Crisis", *Space Policy*, August 1987, p.183.
9. J.R. Asker, "US Begins Push for New Launcher", *Aviation Week & Space Technology*, 19 September 1994, p.22.

Fig. 4 Effect of non-recurring cost recovery on launch price.



Inmarsat Selects Ariane

Inmarsat has decided to award a contract worth $66.5 million to Arianespace of France for the launch of an Inmarsat-3 satellite on its Ariane 4 rocket. In addition to Arianespace, bids to launch the fifth Inmarsat-3 satellite were received from General Dynamics and DB Salyut/ Krunichev. Orders have already been placed for two Inmarsat-3 spacecraft to be launched by General Dynamics' Atlas Centaur, one on an Arianespace Ariane rocket and one on a Krunichev Proton.

'Shuttle Dimensions' Competition Winners

Winners to whom CD prizes will shortly be despatched are:

A. Flockton	W. Yorkshire
W.G. Maxwell	Banffshire
E.A. Mitchell	Essex
P. Stevenson	Glasgow
R. Ward	Sheffield

The correct answers are: 1. 37.2; 2. 23.8; 3. 4.6; 4. 18.3; 5. 46.9; 6. 8.7; 7. 45.4; 8. 3.7.

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Two Ariane Launches in 25 Days

Flight 68

Arianespace has successfully launched two telecommunications satellites, Solidaridad 2 for Mexico, and Thaicom 2 for Thailand, following the launch of Solidaridad 1 and Thaicom 1 less than a year ago. The launch vehicle for Flight 68 was an Ariane 44L, the version of the European launcher equipped with four liquid-propellant strap-on boosters. Lift-off from the Space Center in Kourou, French Guiana, took place on 8 October.

Solidaridad 2 (2,776 kg at liftoff) is the second second-generation satellite operated by Telecomunicaciones de Mexico.

Thaicom 2 (1,080 kg at liftoff) is the second satellite launched for Shinawatra Satellite Public Co. Both satellites are built by Hughes Space and Communications of California.

Flight 69

On 31 October, Arianespace launched Astra 1D, the fourth direct TV broadcasting satellite operated by the Luxembourg-based Société Européenne des Satellites.

The launch vehicle for Flight 69 was an Ariane 42P, the version of the European launcher with two solid-propellant strap-on boosters.

Astra 1D (2,924 kg at liftoff) uses the HS601 platform built by Hughes Space and Communications of California. All four Astra satellites have been launched by Ariane vehicles.

STS-66 Launched

On 3 November the space shuttle Atlantis lifted off from Florida at 11:59 am EST with five US astronauts and one from Europe at the start of an 11-day flight to study the Earth's atmosphere and ozone layer. (Spaceflight, September 1994, p.316).

The mission was the last shuttle flight of 1994 and the first for Atlantis since 1992 as it has been undergoing extensive modifications to enable it to dock with the Mir space station in 1995.

Crew members were Don McMonagle, commander; Curt Brown, copilot; Ellen Ochoa, payload commander; NASA mission specialists Scott Parazynski and Joe Tanner; and French mission specialist and ESA astronaut Jean-Francois Clervoy.

The launch provided a 'First' for the European Space Agency, namely that of having two ESA astronauts in space at the same time as ESA astronaut Ulf Merbold of Germany had been aboard Mir for about a month.

(Activities on Mir and details of the Euromir mission will appear in forthcoming issues of **Spaceflight.***)*

Solar Wind Research

On 1 November NASA's Wind spacecraft was launched at 4:31 am EST on a Delta II rocket from Cape Canaveral. It will spend two years studying the solar wind, and its effects on the Earth and its atmosphere. Its payload includes six US instruments, one from France and the first Russian instrument to fly on a NASA spacecraft.

Ariane 5 Schedule Firmed Up

Ariane 5 development is on schedule and ESA and the French space agency (CNES) confirm that the 501 flight remains on schedule with 29 November 1995 as the target launch date. The four satellites of Cluster, one of the projects in ESA's science programme, will be passengers on that flight. The 501 flight date means that the date of 3 April 1996 can be maintained for the 502 flight. The first operational Ariane-5 flight (503), to be conducted under the responsibility of Arianespace, remains scheduled for October 1996.

Testing of the launcher's main components (P230 solid booster, H155 cryogenic stage, L9 storable-propellant stage) and the associated ground infrastructure proceeds on schedule:

- Of the seven planned full-scale firings of the P230 solid booster, four have been successfully carried out to date (20 October). In the most recent test, which took place on 30 September, the configuration of the booster was similar to the in-flight configuration in many respects.
- Since 5 September, the H155 cryogenic stage has been undergoing a campaign of "battleship" tests using a reinforced (battleship) stage which is fixed to the launch table and connected to the fluids and electrical systems in the launch zone. With this set-up it is possible to validate all filling and draining operations, together with engine pre-cooling, ignition and operation and any associated malfunctions.
- The L9 storable-propellant stage successfully completed its first long-duration test (1075 seconds) on 5 October.

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-63	2 February	Discovery	8 Days	Spacehab-3, Spartan-204, CGP/Oderacs-2	51.6
STS-67	23 February	Endeavour	13 Days	ASTRO-2	28.5
STS-71	24 May	Atlantis	9+1 Days	Mir-01 Mission	51.6
STS-70	July	Discovery	5 Days	TDRS-G	28.5
STS-72	September	Endeavour	9 Days	Spartan, SSBUVA	28.5
STS-73	September	Columbia	16 Days	USML-02	28.5

STS-68 Mission Ends at Edwards

At 1:02 pm on 11 October, Endeavour and its six astronauts landed in California after NASA decided that it was too cloudy at the KSC runway.

During the 11-day environmental research mission, the crew worked in two shifts around the clock surveying the Earth with the Space Radar Laboratory. It was the second flight of the laboratory since April, the object of this flight being to detect seasonal and human-induced changes that had taken place during the six months between missions. About 1,800 researchers gathered data at some 20 key sites on the ground. Details of the mission are to appear in a forthcoming issue.

India Puts Satellite into Space

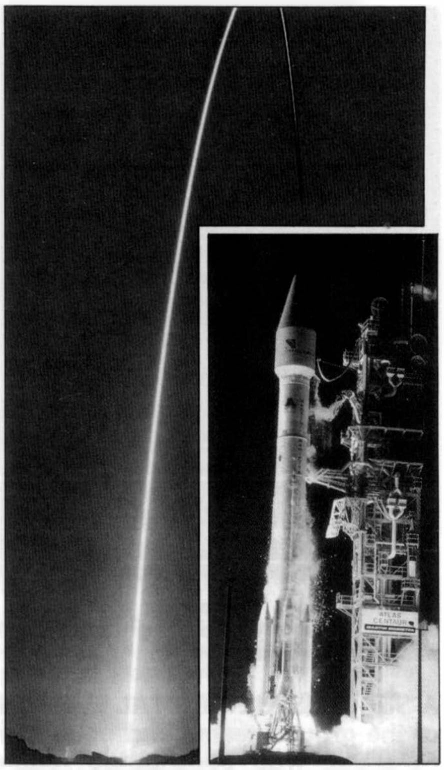
On 15 October India successfully launched an 870 kg remote sensing satellite into orbit aboard the Indian-made Polar Satellite Launch Vehicle (PSLV) from Sriharikota, on the coast of the southern state of Tamil Nadu near Madras. It was the second launch of the PSLV. The first, 13 months ago, ended in failure when it developed problems between its third and fourth stages. This time the 283-tonne rocket soared into space without a hitch and advanced India's ambitious plans to enter the commercial space launch vehicle market.

Intelsat 703 Launched by Atlas IIAS

At 2:35 am EDT on 6 October an Atlas IIAS successfully launched the Intelsat 703 communications satellite into geosynchronous transfer orbit from Complex 36, Pad B at Cape Canaveral. The launch was delayed 42 minutes, first because of a minor technical glitch in ground equipment, then to avoid crossing paths with Russia's Mir space station on the way up.

This was the fourth successful Atlas launch of 1994. The Atlas IIAS, designated AC-111, is the highest performing variant of the Atlas family presently launching satellites for domestic and international customers. It incorporates four Thiokol Castor IVA solid rocket boosters, which increase the total thrust of the launch vehicle to 620,500 pounds. Atlas IIAS is capable of placing satellites in the 7000 to 8000-pound weight class into geosynchronous transfer orbit. The first Atlas IIAS launch took place in December 1993.

Intelsat 703 is the second of Intelsat's newest generation of spacecraft to be deployed in the Pacific Ocean region and will begin operations in December. It will bring Intelsat's in-orbit fleet to a total of 22 satellites providing broadcasting, telephone and other business services to its global network serving more than 200 countries and territories. (See *Spaceflight*, November 1994, p.368).



Launch of the second Atlas 2AS, the most powerful variant of Atlas with four strap-on solid rockets, which carried Intelsat 703 into an elliptical geosynchronous transfer orbit on 6 October. The time exposure was for six minutes and shows Atlas climbing out of the frame before arcing over and re-entering the picture as it continued its flight over the Atlantic.

PETER GUALTIERI, WEST KENTUCKY NEWS

'Weather Satellites' Competition

Television programmes now give weather forecasts in which pictures of cloud patterns are shown that have been snapped from overhead only an hour or so beforehand. None of this was possible before 1960 when TIROS-1, the first research weather satellite, was launched. This month's competition asks three questions which look at the past, present and future of weather satellites and offer readers the opportunity to win a prize.

Prizes: The first correct entry to be opened after the closing date of 5 January 1995 will receive a copy of the book:

Space Satellite Handbook

by A.R. Curtis

This book provides comprehensive text and data about satellites and has recently been published in its third edition. Details of its contents appear in Book Notices on p.358 of the October issue.

The next two correct entries will receive a copy of the authorized biography of Arthur C. Clarke which has been autographed by him:

Odyssey **by Neil McAleer**

To Enter: Answer the following three questions:

1. What does the acronym TIROS stand for? ....
2. Which geostationary satellite has been operated at 75 degrees W to temporarily fill the gap in the global observing system created by the loss of a USA GOES satellite? ....
3. Give the name of the operational satellite series that will start the European meterological polar mission in year 2000 ....

Post to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England
To arrive by first delivery on 5 January 1995.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

Title/Name ....

Address ....

....

....

Discovery heads for its 19th orbital flight. This picture was taken by astronaut John H. Cooper Jr., who was piloting the Shuttle Training Aircraft (STA) from which the weather was being monitored. **NASA**

A SUCCESSFUL ORBITAL FLIGHT of the Shuttle owes much to the efforts of the ground teams and none more so than to the payload team. ***Roelof Schuiling,*** **who contributes regular reports to** ***Spaceflight*** **on Shuttle Missions, gives a personal account of his involvement in the STS-64 mission as Payload Manager and takes readers 'behind the scenes' at the Kennedy Space Center in the run-up to the launch.**

I was seated at the Payload Manager's console in Firing Room Two of the Kennedy Space Center's Launch Control Center as lift-off time at 4:30 pm on 9 September approached and, like everyone around me, my attention was on the Air Force weather screen on the closed circuit television.

The countdown had gone exceptionally well. It had been picked up at 10:30 pm on the evening of 6 September 1994 and no major problems with Discovery or at the launch pad had been found. Loading the external tank with more than 500,000 gallons of propellants had begun a bit ahead of scheduled at 7:45 on the morning of 9 September and was completed at 10:45 am.

The weather however did not look good for a 4:30 launch. Although we were optimistic that a launch was going to be possible on the 9th, it appeared that as 4:30 approached East Florida's weather would not support a launch at the beginning of the launch window. However, with two and a half hours of launch window we were optimistic for the day and hoped that the obstinate weather would dissipate as the evening wore on.

It was not surprising then, to hear the Launch Director call for an extension of the last planned built-in-hold at T-9 minutes. This hold is planned for ten minutes but we would stay holding until the weather looked promising. With nothing to do but watch, the moments in the hold stretched out longer and longer. We could see that the weather in the Launch Complex 39B area was improving and the local Air Force weather group finally gave a clear to launch. We were not ready yet, however, as the Return to launch Site (RTLS) abort weather restrictions were still in effect since several possible thunderstorm debris clouds west of the KSC landing site still posed a threat. We could hear the Shuttle Training Aircraft (STA), which was being used as a weather surveillance aircraft, talking to the weathermen on the ground and we could clearly see on the satellite views on our consoles that there were still a few areas of possible threat.

Although the threat was dissipating, we could also see that the area near KSC was the only clear area in East Florida. The Launch Director elected to continue the countdown and hold at the T-5 minute mark. Although not a planned hold point, T-5 minutes was the last point at which an extended hold could take place. We heard the analysis of LOX drainback indicate that if a hold were called after T-5 and counting the limit would be 5 minutes and 36 seconds. In other words - once the countdown was past the minus five minute period we would have only about five and a half minutes of possible hold time before having to scrub.

Finally the weather sweeps being made by the STA showed that there was no longer a threat to a possible RTLS abort from the weather patterns to the west of us. The countdown was picked up at T-5 minutes and was closing in on T-0 seconds. I was able to watch as a recorder on the LITE payload was turned on by a command from Mission Control at Houston and see the indications on our console in the KSC Firing Room that the recorder was running correctly.

The final two minutes seemed to drag on and on until main engine start. The final few seconds then rushed by and at 6:22:35.042 pm on 9 September the Solid Rocket Boosters ignited and Discovery lifted off on STS-64 - the 19th trip into orbit for Discovery.

* * *

On 1 December 1993 the first of the STS-64 payloads to arrive at KSC had been the LITE (Lidar In Space Technology Experiment). We had shipped a Spacelab programme pallet up to NASA's Langley Research Center (LARC) in Virginia earlier so that the LARC team could install the LITE instrument which they had developed onto the payload bay.

On the day of LITE's arrival at KSC the team performed a laser atmospheric firing test late that evening before transporting LITE to the KSC Operations and Checkout facility where the pallet subsystems would be installed. The subsystems included data, thermal control, and power components. The laser firing test beam was a vertical firing and we had to coordinate operations not only with KSC and the Air Force test range, but also with the Federal Aviation Administration in case any aircraft were in the area. All of our coordination efforts were complicated by the STS-61 launch preparations. STS-61 was then in the final hours of its launch countdown and taking up many of the KSC resources. However, the laser firing went off successfully and the instrument development team was quite pleased that it all went so well.

The next few months were spent with LITE in the KSC Operations and Checkout (O&C) building. Originally built for the Apollo spacecraft checkout operations in the 1960s, the O&C building now houses much of the KSC Shuttle payload operations including office space and test areas. The test and assembly white room high bay work area is an 800 foot long array of test stands of the size of a Shuttle payload bay, payload support structures, cables, test sets, support equipment, scaffolding and payload components. The Spacelab program payloads are the primary users of the facility today and Spacelab components such as laboratory modules, tunnels (connecting to the orbiter cabin), instrument pointing systems, Spacelab pallets and pallet computer containers fill the area. The control rooms for the tests are adjacent to this area. During LITE's stay in the O&C we had to share space and resources with the Shuttle Radar Laboratory (SRL), International Microgravity Laboratory (IML-

2), ATLAS-3 and several other payloads. With so many test stands and payloads, and pieces of payloads, the O&C high bay area can be quite crowded.

During this time we were busy installing the cables, coolant lines and data handling components that are part of the pallet subsystems. These subsystems enable the instrument to communicate with and utilize the Shuttle's payload support systems. They had to be installed after the pallet returned to KSC since the LITE/pallet combination was road-transportable and adding the subsystems at Langley would have prevented the payload from fitting into our only payload transport unit that could negotiate highways.

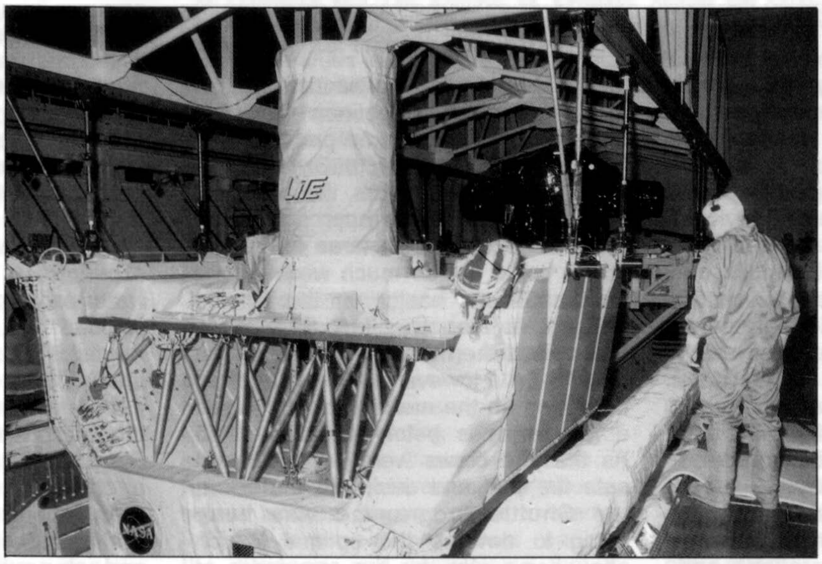
Since I was busy with the launch, landing and deintegration of the STS-60 payloads during much of this time, I was glad we were not into a heavy test schedule until April. Much of April was taken up with the testing of the newly-installed pallet subsystems in preparation for hooking them up to the LITE instrument. After completing this phase we were ready to begin testing the LITE instrument together with the subsystems to check out the payload as a complete unit.

The experiment functional test (as it was termed) used an O&C checkout station to control a major portion of this testing. However, the SRL-2 payload also used the checkout station and, since it was then set to launch in August and we were set to launch in September, the SRL-2 had a higher priority on its use. We had to work our test operations around SRL-2's schedule and we began testing in late May.

The experiment functional test operations took eleven days over a three week period. As in most test operations we had a number of results which were not expected and needed additional test time to be resolved. However, by mid-June we were ready to proceed with the next phase of the LITE test operations.

This involved moving LITE into a test stand that simulated the Shuttle orbiter's electrical and avionics interfaces so that we could checkout LITE's ability to communicate with the orbiter before we actually installed it in the payload bay. We spent about two weeks checking out these interfaces. Here also, we had to work our schedule around SRL-2's since we needed the O&C checkout station to handle many of the LITE command and response lines.

This was a busy time as the SPARTAN-201 payload had arrived at the O&C together with a GAS (Get Away Special) canister trusswork bridge with a series of GAS canisters. After testing LITE was placed into a transportation canister together with the SPARTAN-201 and the GAS Bridge for delivery to Discovery. During this period we also took the Robot Operated Materials Processing System(ROMPS) secondary payload out to Discovery for installation. ROMPS was a wall-mounted Goddard Space Flight Center experiment which, since it was a wall mount, was not installed with the cross-bay mounted LITE, SPARTAN-201 and GAS Bridge. ROMPS, SPARTAN-201 and GAS Bridge had not required extensive assembly and test prior to installation in the orbiter.



On 7 July the three payloads LITE, SPARTAN-201 and GAS Bridge were lifted out of the transportation canister and lowered together into Discovery's payload bay in the Orbiter Processing Facility. NASA

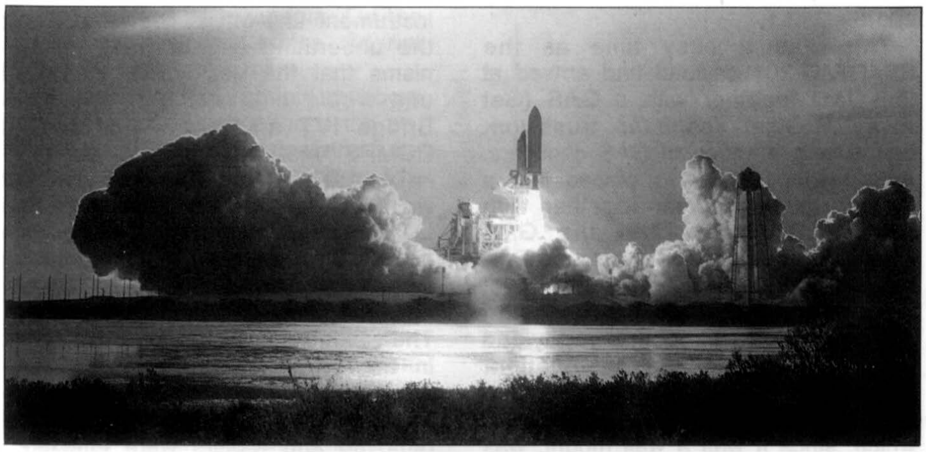
We also had a number of reviews to verify that the payloads were ready for their installation in the orbiter. A KSC Payload Readiness Review for management was held on 21 June and the LITE programme underwent an Independent (e.g. a non-LITE review board) Review at Langley on 28 and 29 June. I had to prepare charts and present an overview of the KSC processing experiences for each of these.

On 7 July the transportation canister containing LITE, SPARTAN-201 and GAS Bridge drove out to the Orbiter Processing Facility (OPF) work bay two. There, the three payloads were lifted out of the transporter together and were lowered together into Discovery's payload bay. After hooking up payload, cables and LITE's coolant fluid lines to the orbiter, the payloads were now ready for the interface tests which would verify that they could work with the orbiter. The SPARTAN-201 interface test (IVT) went well and included using a crane to lift the instrument unit off its carrier to check the unberthing and berthing mechanisms that the deployable instrument unit would use in flight. The GAS Bridge IVT also went well as did ROMPS' test.

The LITE IVT was running well, but we ran into two problems when the LITE instrument was powered on. One dealt with erroneous readings from the instrument's engineering data system and was traced to a bad power supply. The second was the discovery of a leak in the laser transmitter's pressurisation system which was traced to a fitting in the unit. Both of these were removed and repairs were effected.

Immediately after LITE's completed IVT we had hoped to be able to run a test of the LITE payload-orbiter-Johnson Space Center network links so that Mission Control could check the LITE ground command uplink and data downlink paths. However this test - called an end-to-end test - had to be delayed until after the STS-65 mission which was then in progress. STS-65 needed too much of the network's capabilities in support of their mission so we had to wait until after STS-65 landed on 23 July to try to fit our test into Discovery's busy schedule. We got a chance to run our end-to-end test late on the 25th and into the morning of the 26th. We also checked out our laser pressure fitting repair and the new power supply - both of which were good.

During the end-to-end test we found that a multiplexer-demultiplexer (termed "smart flexible" as it contained microprocessor capabilities) on the LITE pallet was stopping for resetting too often. We had occasionally had a reset it during test operations when the LITE instrument was on but at quite long intervals. Although it took only a moment to reset, there was some concern that seeing five of these in one evening's tests might indicate the unit was failing. It was decided to replace the LITE smart flex with the one which had flown on the Tethered Satellite payload on STS-46. This was done and the new smart flex required one reset in 29 hours time - about what the old one had. Since bench tests of the old unit failed to show anything wrong and the old unit never required reset during many days of bench tests, it appeared no problem had existed and a random interaction with the LITE instrument was the causative factor. Later, during the actual mission, the



Due to the nearly two-hour delay the launch occurred as evening was just beginning to darken and Discovery's rocket engine flames were an almost painfully white light against the background of a setting Sun. PETER GUALTIERI, WEST KENTUCKY NEWS

same pattern of widely separated occurrences repeated and the unit was reset each time with no impact to successful operations.

During the payload's powered up testing, while in Discovery's payload bay, the majority of the payload test team was located in the Launch Control Center in one of the two prime firing rooms for control of the test operations. Our STS-64 mission was using Firing Room Three. The testing days usually run long and we were powered up for five days with LITE alone. Before the LITE instrument could be powered on and the complete LITE-orbiter links tested the orbiter had to be powered up in a configuration to support payload test operations and its computers configured to support payload operations. Most of the KSC Shuttle test operations are in a computer configuration that supports launch and ascent. However payload operations usually need a computer configuration that supports an on-orbit activity as payload operations typically begin after the Shuttle begins orbital mission operations. Both the Shuttle and the Launch Control Center computers have to be reconfigured to support payload activity. For LITE, after the orbiter and launch Control Center were ready the pallet and subsystems had to be brought on line and checked. Only after all of this could the LITE instrument itself be powered on and the main part of our testing begin.

With all of the payload operations completed in the OPF we were ready for the orbiter crews to close the payload bay doors in preparation for the rollover to the VAB. There, Discovery was mated with the Solid Rocket Boosters and External Tank on 10 August. Of course we had another major review - the Orbiter Rollout Review - before we could leave the OPF. Again, I presented the payload position and my summary was that we were ready to go to the launch pad.

STS-64 remained in the VAB a few extra days due to the planned STS-68 launch on 18 August. We wanted to let the STS-68 Endeavour launch go before we arrived at Launch Complex 39B. Although there is no problem with having one Shuttle on 39B while another is launching from the adjacent 39A, our pad and its approach roads would be in the danger area for launch so we could not do much work on our Shuttle. It was easier on the Shuttle pad crews also to allow STS-68 to launch and then turn their full attention to STS-64. However, STS-68 aborted its launch on the morning of 18 August a few seconds before planned liftoff! As the pad crews were scrambling to safe the pad and deal with the abort, the Shuttle programme was busy trying to develop the optimal launch sequencing plan for the remainder of the year.

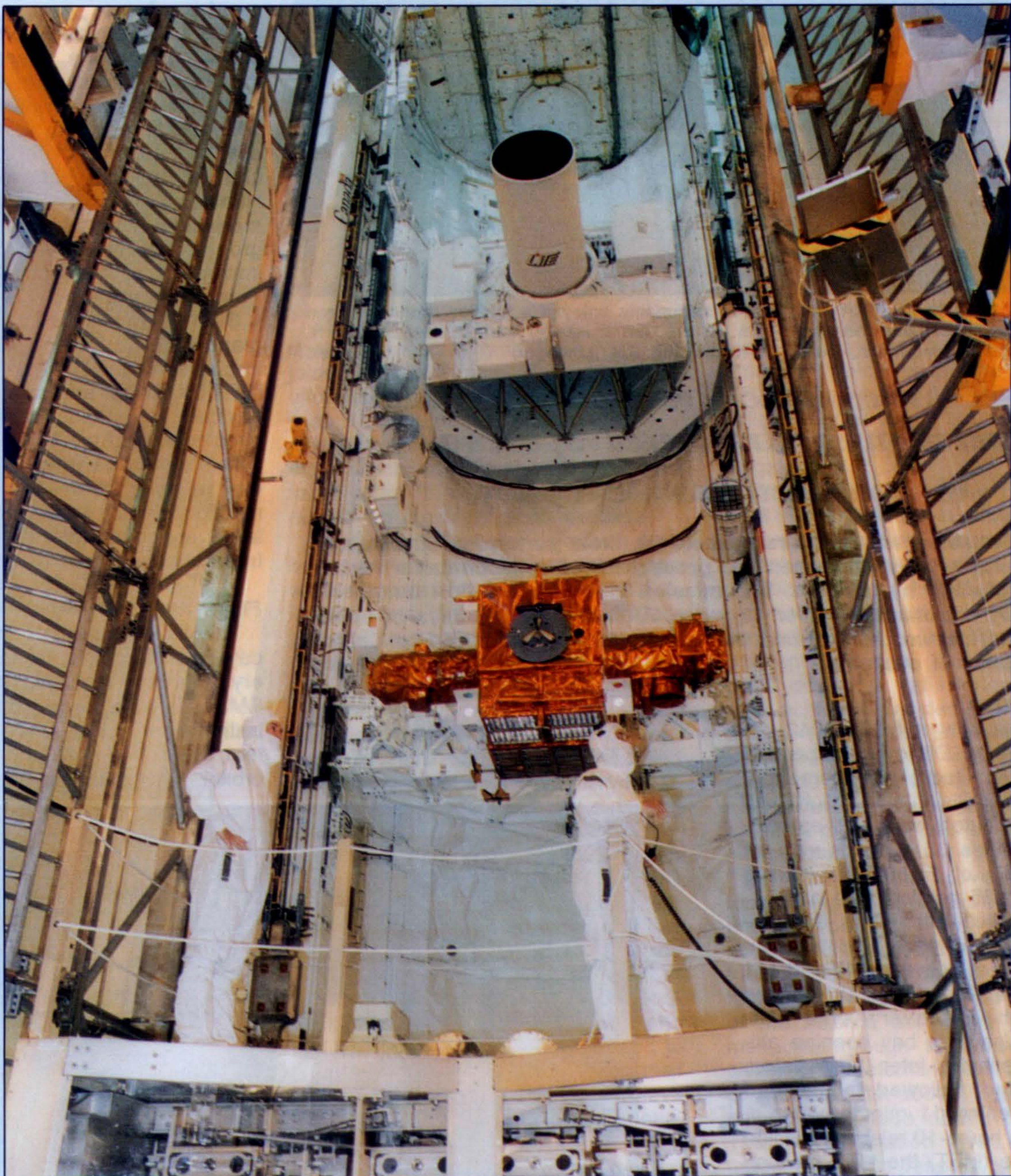
Although it may have appeared to the outside world that KSC simply maintained the STS-64 and STS-66 schedules and fitted another STS-68 attempt between them, it was nowhere near that simple. On the afternoon of the 18th we had a preliminary KSC meeting to assess possible options. I was not happy to see that one of the more probable options had STS-64 launching after both STS-68 and STS-66. There were a variety of issues including the fact that the Air Force tracking range already had a number of expendable launch vehicles launching in the latter part of September and the STS-64 mission might only have a few possible launch days before having to give up the range until early October. Also, it was hurricane season and we had to be aware of the dangers of having more than one Shuttle on a launch pad for an extended time as a hurricane threat might mean having to roll back into the VAB even if the hurricane were only a threat - not an actual hit - to KSC. The Shuttle programme also had to consider the replacement of Endeavour's engine and the testing of the engine that had caused the abort.

In a Shuttle programme-wide telcon later that afternoon the various NASA centres considered all of these as well as many other factors. I was sitting in on this meeting also and it was becoming evident that the programme was centring in on launching STS-64 next. I was holding my breath at many points and when a factor supporting STS-64 as next launch was brought out I found myself silently cheering them on. At last the meeting was over and the STS-64 people walked out with a virtually unchanged schedule. We could not have done any better than that!

Discovery was rolled out to the launch pad the next day and began operations at Launch Complex 39B with a planned 9 September launch date. The vast majority of payload operations had been completed at this point. While the Shuttle went though its normal routine of pad operations all we really had left to do with the payloads was to make one more check of the laser pressurisation system to insure no slow leak was present, remove some instrument covers, install a SPARTAN flight battery for launch, and install two cabin middeck locker experiments. The payload bay doors were only opened for access to the payloads for two days at the end of August. The pressure test went well and I joined many of our payload developers and test crew for a last check on the payloads on 30 August after Discovery's payload bay doors were opened.

To get out to the Shuttle I had to drive out past the Launch Control Center and along the Shuttle's crawlerway path to the pad and go through a guard check of my area permit at the pad gate. I then drove up the long concrete approach slope to the pad surface. From the surface the elevator took me up to the 135 level for entrance to the payload work area. When one gets off the elevator at the 135 level the Atlantic Ocean appears to the East through a forest grove-like expanse of gray iron service structures and walkways. To the West is an expanse of Florida scrub and swamp leading off to the Launch Control Center and VAB three miles away. The payload work area (termed the Payload Changeout Room or PCR) covers the top of the Shuttle orbiter from tail to cabin and provides a sheltered area to provide access to the payload bay. The PCR door is on the opposite side of the structure from the elevator and we had to walk around the PCR along a narrow catwalk with nothing below except the pad flame trench. Although a bit unsettling at times, the view is spectacular.

Inside the structure, I put on a white "bunny suit" that covered me from head to foot and went inside the PCR work area through an air shower. The area was brilliantly lit inside the PCR and at the various levels of the work stands adjacent to the open payload bay there were several dozen bunny suited figures working to complete the



Just before closing the payload doors in readiness for the countdown to begin. NASA

final payload work. High above us at the top of the orbiter payload bay was the LITE payload which looked like a large telescope sitting in a bathtub. Further below, or back, in the bay was the SPARTAN-201 and the GAS Bridge. The payload bay is lined with white insulation or white paint. The overall effect reflects the bright lights of the PCR like noon in a gardener's greenhouse.

After completing the final payload checks and removing instrument covers we closed the payload bay doors and were ready for the countdown to begin. But not, however, before another series of management reviews. The Launch Readiness Review confirmed KSC's readiness to launch and several days later the Flight Readiness Review confirmed the Shuttle programme and supporting organisations were ready for the STS-64 mission. A final series of management reviews on Launch Minus Two and One days verified no issues had arisen since the Launch and Flight Readiness Reviews. I presented the payloads' status and contingency plans during the Launch Readiness Review, then I could relax and watch as our directors presented payloads' positions at the Flight review and at the Launch Minus Two and Minus One Day reviews. I could not relax entirely, however, as I joined Shuttle and weather representatives for routine formal press conferences on the two days prior to launch.

KSC's final payload operation was the installation of the last middeck science experiment - Biological Research In Canister (BRIC) - at the Launch minus 17 hour point.

The final weather delay described at the beginning dragged on for us in the Firing Rooms, however we felt that 9 September would be "the day". The delay caused the launch to occur as the evening was just beginning to darken and Discovery's rocket engine flames were an almost painfully-white light arcing out across the sea and up past the North American coastline on a 57 degree inclination path. September 9 was a Friday so after the traditional post-launch cornbread and beans we had a weekend to relax before having to work out the details of post-landing payload removals and deintegration. . . . And also to continue the planning for my next missions, STS-63, STS-70 and STS-72. ■

With liftoff set for 4:30 pm (EDT), the STS-64 astronauts enjoyed a midday brunch instead of the typical early morning breakfast. From left are Carl J. Meade, Mark C. Lee, Richard N. Richards, Blaine Hammond Jr., Susan J. Helms and J.M. Linenger. NASA

Laser Atmospheric Research • Robotic Operations • Untethered Spacewalk

Mission Operations Day-by-Day

Discovery's mission saw two firsts when the crew performed atmospheric research using a laser and when the processing of semiconductor materials was conducted by robotics. The mission also saw the first untethered spacewalk by astronauts in over 10 years. After a busy ten days of operations, the Florida weather caused the landing to be transferred to California with a delay of one day.

BY ROELOF SCHUILING
at the Kennedy Space Center

Flight Day One

Following launch at 6:22:35.042 pm on 9 September, Discovery separated from the Solid Rocket Boosters at 2 minutes 4 seconds into the flight and main engine cutoff came at approximately 8 minutes 35 seconds with an orbiter velocity of 25,800 ft/s leading to a 125 by 135 nautical mile orbit.

At 36 minutes after liftoff the manoeuvring engines were fired to circularise the orbit at between 140 and 141 nautical miles. At 1 hour 12 minutes after launch Discovery was manoeuvred to payload bay opening attitude and 5 minutes later the radiators were activated, followed by payload bay door opening 11 minutes later.

At about 2 hours 10 minutes Mission Elapsed Time (MET) the LITE payload (Lidar In-Space Technology Experiment) pallet was activated and the LITE instrument was activated at approximately 2 hours and 40 minutes MET.

The SPARTAN-201 was activated for checks about 15 minutes later and ROMPS (Robot Operated Materials Processing System) activation came at about 3 hours and 5 minutes into the flight. ROMPS operations began while the crew were having their first sleep period at about 7 hours into the mission.

Mission Commander Richard N. Richards initiates a thruster firing during operations with SPIFEX (Shuttle Plume Infringement Flight Experiment) on Flight Day Two. NASA

Flight Day Two

With Discovery in a 57 degree orbit, the mission began its first full day in space with an assortment of experiments.

The LITE payload completed three orbits of nighttime observations over the eastern hemisphere of the Earth, taking laser measurements of aerosols above northern Europe, clouds over Indonesia and the South Pacific, and the surface characteristics of the Himalaya mountains. Simultaneous measurements were performed by ground observers and by the LITE instrument of the atmosphere above Tomsk, Russia.

Susan Helms used the RMS to grapple the 32 foot long Shuttle Plume Impingement Flight Experiment (SPIFEX) boom and raise it above the payload bay. Cold nitrogen gas was directed toward the SPIFEX in order to calibrate sensors which would be used later to study the effects of Discovery's reaction control system jet plumes on large space structures such as the International Space Station.

Flight Day Three

The crew spent the first half of their day continuing the studies of Discovery's thruster exhaust plumes. The RMS was used to position the SPIFEX instruments above Discovery's thrusters, both in the nose and the tail of the orbiter. The instruments were used to characterise the heat and pressure from single and dual thruster firings to help plan Shuttle docking operations with the Mir space station and the International Space Station.

On the aft flight deck, Susan J. Helms handles controls of the RMS arm which was used for SPIFEX operations, the SPARTAN-201 release and retrieval and the six-hour EVA on Flight Day Eight. NASA

For the remainder of the day, the mission focus was on operations using the LITE laser instrument which was active during three successive orbits. The crew also exercised as they evaluated a new type of treadmill.

Overnight, the Goddard Space Flight Center's Robot Operated Materials Processing System (ROMPS) continued operating while the crew was asleep. It was controlled from the ground and was the first such US

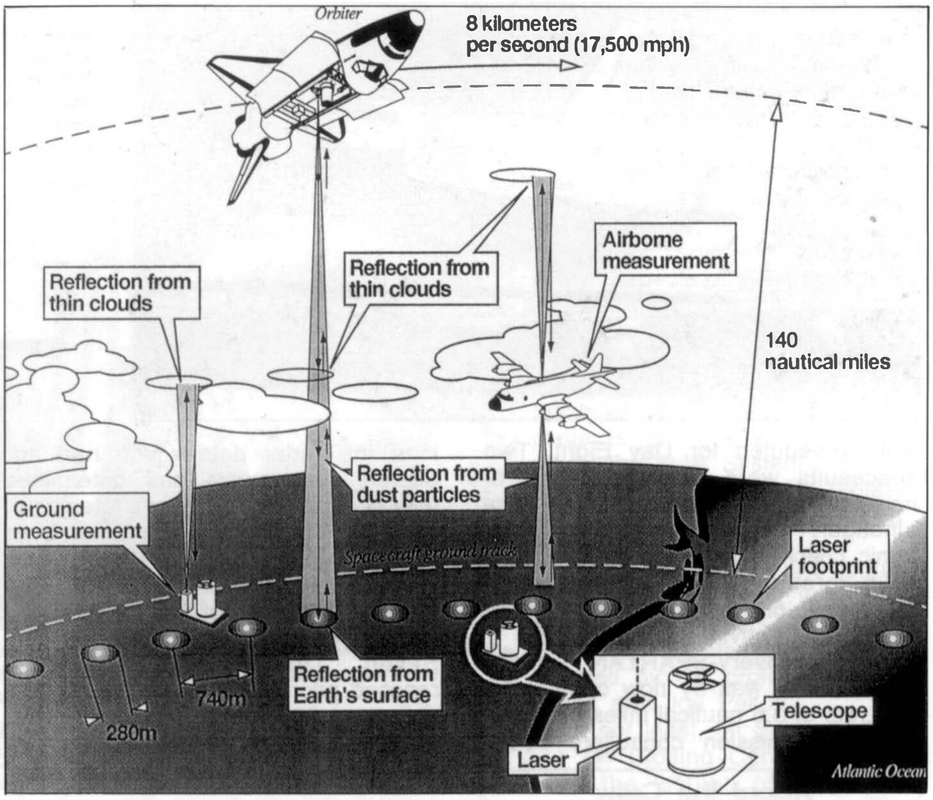
robotic unit to be used in space. It transported semiconductor materials from storage racks to a halogen lamp furnace for heating.

Flight Day Four

Final studies of the orbiter's thruster exhausts using SPIFEX and further LITE instrument observations marked STS-64's fourth day in space. The boom was reberthed on the right side of the orbiter's payload bay so that the RMS would be ready to support SPARTAN-201 deployment operations on the fifth day of the flight.

LITE completed observations of smoke in the atmosphere above portions of South America, the sea surface in the mid-Atlantic, clouds above Central America, and the upper atmosphere above northern Europe. The laser radar made observations during both day and night passes. Several precisely targeted sites required Commander Dick Richards to aim the laser by altering Discovery's orientation, while other sites were surveyed by using a slow rocking of the orbiter to create a sweep with the laser pulse. Ground and airborne instruments were in use to make concurrent measurements to correlate with the LITE data.

The crew retired for the night at 11:23 pm.



The LITE instrument in operation with supporting ground and airborne measurements. NASA

Flight Day Five

Discovery's crew was given the go-ahead for an additional day in space after mission managers evaluated the electric power usage for the mission. The latest margins showed electrical power margins would provide enough fuel cell reactants to support an additional day of science data gathering. The landing was reset for the afternoon of 19 September.

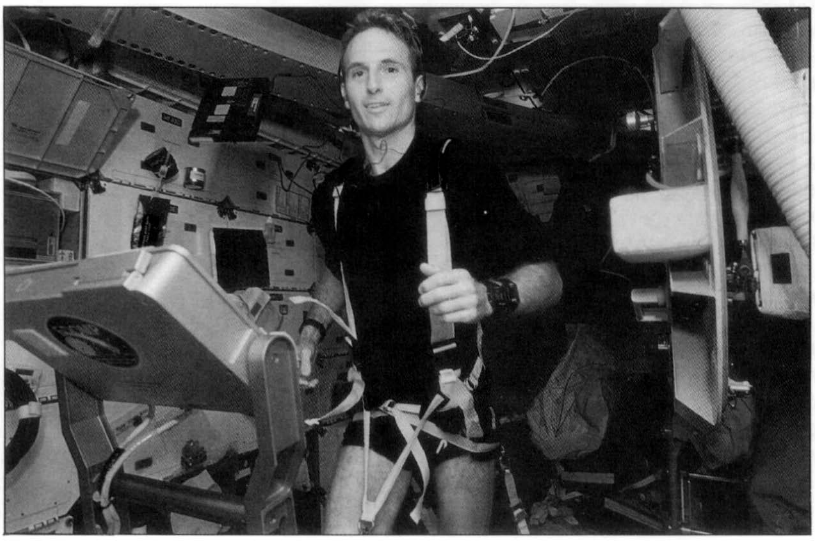
The major activity for the day was the release of the SPARTAN-201 satellite. The RMS robot arm was used to lift the SPARTAN out of the payload bay and release it at 5:30 pm. Discovery then performed three separation manoeuvres to slowly move the orbiter away from the satellite to a position 50 miles behind it. SPARTAN has pointing capability but no translational capability, therefore the orbiter had to move away from, and return to, the satellite. During deployment, the orbiter's rendezvous radar provided data that appeared to be questionable and mission controllers began analysing the readings to determine the cause.

Two orbits after its release, SPARTAN began its studies of the solar wind and solar corona.

The crew then continued operations with LITE to study the Earth's atmosphere. Ten different groups from Japan, China, Puerto Rico and the United States took measurements of the Earth's atmosphere from the ground at the same time that LITE was taking measurements from space.

ROMPS operations, under control from the ground, continued during the crew's sleep period, completing over 70 of its 100 samples by the time the crew awoke.

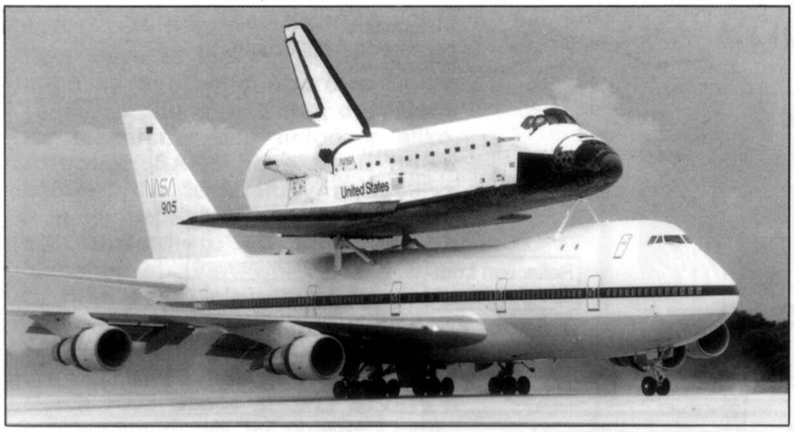
Jerry M. Linenger works out on the treadmill device on Discovery's mid-deck. NASA



Mark C. Lee monitors the LITE at work in Discovery's cargo bay. Near his head is a 100 mm lens used to collect data on cloud formations. NASA

Flight Day Six

Equipment was checked out and readied for the untethered EVA space-



Left: **Discovery returns to KSC on 27 September, one week after weather diverted it to Edwards following the successful completion of STS-64. A cloud of dust follows the Shuttle Carrier Aircraft (SCA) as it rolls down the runway. Dark clouds almost further delayed the return to KSC as the SCA is not allowed to fly through rainshowers when carrying a shuttle.**
PETER QUALTIERI, WEST KENTUCKY NEWS

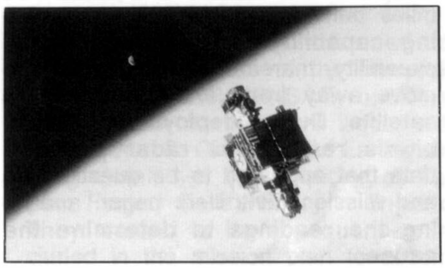
(See below for how a shuttle is loaded and unloaded from the SCA.)

walk scheduled for Day Eight. Two spacesuits were checked by astronauts Mark Lee, Carl Meade and Jerry Linenger. They also tested an electronic checklist mounted on the spacesuit forearm which provides computer data on various aspects of the spacewalk activity.

The Discovery-SPARTAN separation distance was by now opening up at a rate of 3.6 nautical miles per hour. Overnight, mission controllers examined the radar data which had appeared questionable and determined they were due to the radar's late acquisition of the satellite about an hour after deployment. The crew began targeting Discovery toward the planned retrieval of the SPARTAN-201 which was scheduled for Day Seven. The furthest separation reached prior to beginning the rendezvous was 60 nautical miles. After two small thruster firings the closing rate was about one nautical mile per orbit.

Flight Day Seven

The primary objective of the day was the planned retrieval of the SPARTAN-201 satellite.



A 70 mm camera shot taken from on board Discovery during the retrieval of SPARTAN-201. The Moon can be seen in the background. **NASA**

Blaine Hammond talks to students via the Shuttle Amateur Radio Experiment (SAREX) on the flight deck. Throughout the mission several of the crew members made contact with schools around the world.
NASA

Discovery continued to close in on the satellite and Susan Helms powered up the RMS robot arm in preparation for the retrieval. The final approach began with an engine burn when Discovery was about eight nautical miles behind SPARTAN-201. Discovery's rendezvous radar system was now performing correctly and at about 3:56 pm Commander Dick Richards took over manual control at a separation distance of approximately one mile.

Flying by means of Discovery's aft flight deck controls, Richards manoeuvred the orbiter to within about 45 feet of the SPARTAN satellite. Susan Helms then used the RMS robot arm to grasp the SPARTAN and bring it into the payload bay where it was berthed into its support structure shortly before 5:00 pm.

About the Crew

Commander ***Richard (Dick) N. Richards***, 48, Capt., USN was selected as an astronaut in 1980 having previously flown as Pilot on STS-28 in August 1989, as Commander of the Ulysses-launching STS-41 in October 1990 and as Commander for the STS-50 mission which was launched in June 1992. He had logged over 22 days and 22 hours in space flight prior to the STS-64 launch.

L. Blaine Hammond, Jr., 42, Col., USAF served as Pilot for the STS-64 flight and had previously flown as Pilot on STS-39 in May 1991. He attended the Empire Test Pilot School in Boscombe Down in 1981 and was selected as an astronaut in 1984. He had over 199 hours of space flight prior to STS-64.

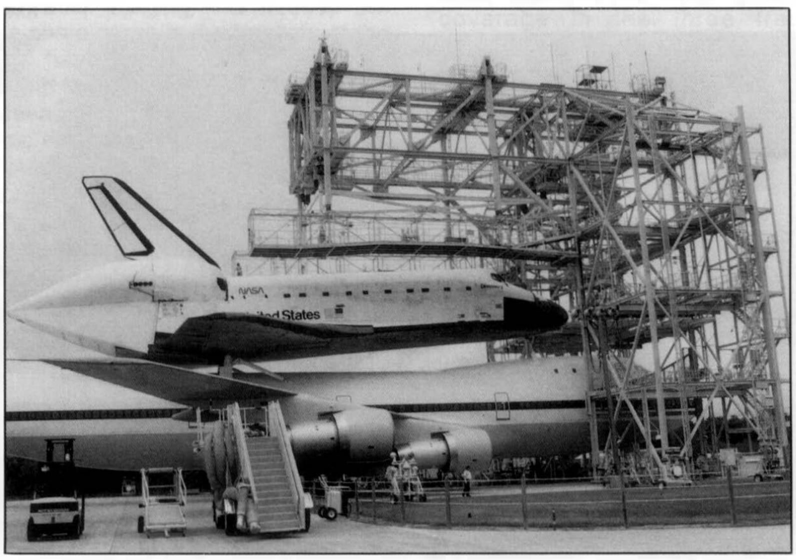
Mission Specialist-One was ***J.M. (Jerry) Linenger***, 39, MD, PhD., Cdr., Medical Corps, USN who was selected as an astronaut in 1992 and was making his first space flight on STS-64.

Susan J. Helms, 36, Lt. Col., USAF served as Mission Specialist-Two. She had been selected as an astronaut in 1990 and was making her second space flight on STS-64 having flown previously on STS-54 and acquiring over 143 hours of space flight.

Mission Specialist-Three was ***Carl J. Meade***, 43, Col., USAF who was making his third space flight on STS-64 having flown as a mission specialist on STS-38 in December 1990 and on STS-50 in June 1992 with over 449 hours of space flight prior to STS-64.

Mark C. Lee, 42, Col., USAF, served as Mission Specialist-Four. He was selected as an astronaut in 1984 and this was his third space flight. He had previously flown on STS-30 to launch the Magellan spacecraft in May 1989 and on STS-47 in September 1992 acquiring over 288 hours in orbit.

Discovery enters under the Mate/Demate Device (MDD) as the SCA is pulled through it. Workers then attach the lifting harness which hangs over Discovery while others work beneath the orbiter to separate it from its mount atop the SCA. **PETER QUALTIERI, WEST KENTUCKY NEWS**



Preparations were then made for the spacewalk set for the following day. The cabin pressure was lowered to 10.2 pounds per square inch and astronauts Mark Lee and Carl Meade performed an abbreviated prebreathing protocol to help cleanse their blood of nitrogen. This would help to prevent "the bends" from occurring when they are operating in the spacesuits at 4.3 pounds per square inch pressure.

The mission also continued with four hours of LITE Earth atmospheric observations, including readings taken over a typhoon. ROMPS scientists reported that the robotic materials unit had completed all of its crystal growth experiments for the flight.

Flight Day Eight

Preparations for the day's spacewalk began shortly after 8:00 am and astronauts Lee and Meade began breathing pure oxygen at 9:36 am. The spacewalkers began their EVA at 10:42 am when they depressurised the orbiter's airlock. The EVA lasted 6 hours and 51 minutes and was the 28th in the Space Shuttle program. They tested a new propulsive backpack called SAFER (for Simplified Aid for EVA Rescue). The SAFER is designed for use in the event of an astronaut becoming untethered during EVA operations.

The SAFER tests involved both astronauts who each had a chance to use the unit. SAFER used nitrogen gas as a propellant. In translation manoeuvres the gas will last 60 seconds while in rotation manoeuvres it will last about 120 seconds. The unit uses a new technology not available until recent years and avoids using gyroscopes by utilising solid state rate sensors in its operations. SAFER is meant to be used only in emergencies - something like a parachute in aviation.

Mark C. Lee tests the new SAFER system as part of a programme to establish a common set of requirements for both Shuttle and Space Station needs. This scene was captured with a 70 mm handheld Hasselblad camera with a 30 mm lens attached. NASA

Flight Day Nine

The crew took advantage of this additional day to gather further data using the SPIFEX and LITE instrumentation. SPIFEX gathered 18 additional points of data in its studies of the effects of the orbiter's thruster jets on nearby structures.

Flight Day Ten

The crew began wrapping up their science studies, the LITE instrument having emitted almost 2 million laser pulses during 53 hours of operations. LITE gathered data on storms, dust clouds, pollution aerosols, biomass burning, stratospheric aerosols and surface characteristics. Ninety-five scientific groups representing 18 countries participated in the instrument's study programme by gathering ground-based measurements as LITE gathered data from space.

ROMPS researchers reported completing all of their objectives and SPIFEX had accumulated 100 data points - 14 more than planned before launch.

Left: **Mark C. Lee gets his height measured by Jerry M. Linenger as part of the daily inflight routine supporting a medical DSO (Detailed Supplementary Objective). The study is designed to collect information about back pain and height changes experienced by astronauts during fight. As an ongoing programme, data will be gathered from 30 astonrauts who spend more than eight consecutive days in space.** NASA

Mark C. Lee (left) and Carl J. Meade during a 15-minute pre-breathe exercise in preparation for their EVA on 16 September. NASA

In readiness for landing the crew began checking Discovery's flight control system at about 9:23 am. They also test fired thruster jets. One of the 38 jets malfunctioned and was turned off as the orbiter still had sufficient steering capability for landing.

The LITE instrument made several more observations, including that of an erupting volcano in New Guinea. The crew began what was then thought to be their last sleep period at about 9:30 pm on Sunday, 18 September.

Flight Day Eleven

Weather at the Kennedy Space Center was uncooperative and mission controllers decided to postpone the landing until the following day as thunderstorms and low clouds would prevent the landing. The crew configured their spacecraft for an extra night in space.

Flight Day Twelve

Two landing opportunities existed at the Kennedy Space Center and two at Edwards Air Force Base, but again, the Florida weather was unsuitable for landing as clouds and rain continued to stay in the KSC area. After the two Florida landing opportunities were cancelled, mission planners decided to land at Edwards Air Force Base on the first of the landing opportunities.

Accordingly, Discovery began its deorbit engine burn at about 4:14 pm and touched down on Edwards runway 04 after completing 177 orbits of the Earth. Main gear touchdown was at 5:12:52, nose gear touchdown at 5:13:04, and wheel stop at 5:13:52 pm on 20 September 1994.

After safing the orbiter and crew removal, Discovery was moved to the mate-demate facility where it was prepared for mounting upon the Shuttle Carrier aircraft 747 transport for return to the Kennedy Space Center. There, Discovery will be prepared for its next space mission, STS-63, now set for February 1995. ■

Hubble Observes Jupiter Impact

Following comet P/Shoemaker-Levy 9's spectacular collision with Jupiter from 16 to 22 July, Hubble Space Telescope astronomers have been analysing the images and spectroscopic data recorded during the impact. Their initial findings, combined with results from other space-borne and ground-based telescopes, have shed new light on Jupiter's atmospheric winds, the mysterious dark debris from the impacts, and the composition of the comet itself.

Last Days of the Comet

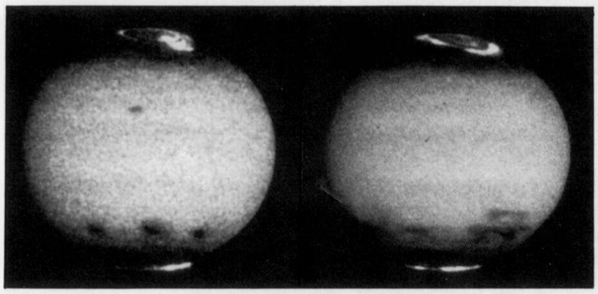
Before the impact, there was a great deal of speculation about whether the comet's 21 nuclei would survive to reach Jupiter or were so fragile that gravitational forces would fragment them. Hubble helped to answer this question by recording the nuclei until about 10 hours before impact. HST's high resolution images show that the nuclei, the largest of which were probably a few kilometres across, did not breakup before plunging into Jupiter's atmosphere, indicating that the atmospheric eruptions observed on Jupiter were produced by solid, massive impacting bodies.

HST's resolution also showed that the nuclei were releasing dust all along the path toward Jupiter, as would be expected from a comet. Spherical clouds of dust surrounded each nucleus throughout most of the comet's journey until about a week before impact, by which time the dust clouds were being stretched out along the comet's path by Jupiter's increasingly strong gravity.

Spectroscopic Observations

Hubble's Faint Object Spectrograph (FOS) recorded dramatic changes as Jupiter's magnetosphere was entered and these changes provided an opportunity to gather evidence of the comet's composition. During a two minute period on 14 July, HST detected strong emission from ionised magnesium (Mg II), an important component of both cometary dust and asteroids. However, if the nuclei were ice-laden - as expected of a comet nucleus - astronomers expected to detect the hydroxyl radical (OH). The HST did not see OH, casting some doubt on the cometary nature of P/Shoemaker-Levy 9. Eighteen minutes after the flare-up in Mg II emissions, there was also a dramatic change in the light reflected from the dust particles in the comet.

July 17, 1994 July 29-30, 1994



HST Wide Field Planetary Camera-2 far-UV (1600A) images reveal the drift of very fine dust in the high atmosphere due to an equatorwards wind. The first image shows the C,A and E impact sites. The later images shows that the spread of debris is mainly in an east/west direction as shown by the near-UV images below, but a fainter cloud of debris also moves equatorwards and this is not recorded on near-UV images indicating an association with very fine dust particles in the high Jovian atmosphere.

J.T. CLARKE, G.E. BALLESTER (U. OF MICHIGAN) and J.T. TRAUGER (JPL) and NASA

The HST Faint Object Spectrograph (FOS) detected many gaseous absorptions associated with the impact sites and followed their evolution over the next month. Most surprising were the strong signatures from sulphur-bearing compounds like diatomic sulphur (S_2), carbon disulphide (CS_2), and hydrogen sulphide (H_2S). Ammonia (NH_3) absorption was also detected. The S_2 absorptions seemed to fade on timescales of a few days, while the NH_3 absorptions at first got stronger with time and finally started fading after about one month. During observations near the limb of Jupiter, the FOS detected emissions from silicon, magnesium and iron that could only have originated from the impacting bodies, since Jupiter itself normally does not have detectable amounts of these elements.

Auroral Activity

The HST detected unusual auroral activity in Jupiter's northern hemisphere just after the impact of the comet's "K" fragment. This impact completely disrupted the radiation belts which have been stable over the last 20 years of radio observations.

Aurorae are common on Jupiter because energetic charged particles needed to excite the atmospheric gases are always trapped in Jupiter's magnetosphere. However, the new feature seen by Hubble was unusual because it was temporarily as bright or brighter than the normal aurora, short-lived, and outside the area where Jovian aurorae are normally found. It is believed that the K impact created an electromagnetic disturbance that travelled along magnetic field lines into the radiation belts and scattered the charged particles, which normally exist in the radiation belts, into Jupiter's upper atmosphere.

X-ray images taken with the ROSAT satellite also support a link with the K impact. They reveal an unexpectedly bright X-ray emission, mainly from the northern end of magnetic field lines connected to the impact site, that was brightest near the time of the K impact and then faded.

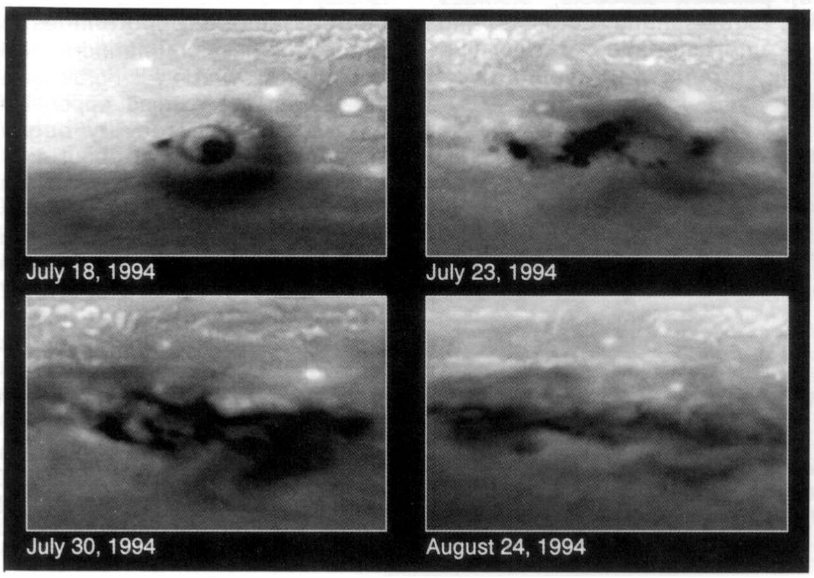
Jupiter's Winds

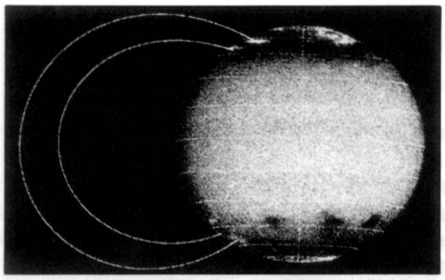
Observations made with HST's Wide Field Planetary Camera-2, a week and a month after impact, have been used to make global maps of Jupiter for tracking changes in the dark debris caught up in the high speed winds at Jupiter's cloudtops. The high speed easterly and westerly jets have turned the original dark "blobs" at the impact sites into striking "curly-cue" features. Although individual impacts sites were still visible a month later despite the shearing, there has been substantial fading and it is clear that Jupiter will not suffer any permanent change from the explosions.

Hubble's ultraviolet observations have shown the motion of very fine impact debris particles suspended in Jupiter's high atmosphere, before they diffuse down to lower altitudes. This has provided the first information ever about Jupiter's high altitude wind patters. At lower (cloud-top) altitudes, the impact debris follows east-west winds driven by solar heating and Jupiter's own internal heat. By contrast, winds in the high Jovian atmosphere move primarily from the

HST Wide Field Planetary Camera-2 images in near-UV light: Jovian winds reveal their presence as the pattern of impact debris is transported and shaped. The first image was taken 90 minutes after the large G impact and also shows a small dark spot to the left which remains from the smaller D impact one day earlier.

H. HAMMEL, MIT and NASA





HST Wide Field Planetary Camera-2 far-UV image taken 45 minutes after the K impact on 19 July 1994. The image shows arc-like auroral emissions near the left limb at mid-latitudes in the north and fainter but remarkably similar emissions near the impact site in the south. Two magnetic field lines are drawn and represent the paths of trapped high energy charged particles that cause the emissions.
JOHN T. CLARKE (U OF MICHIGAN), and NASA

poles toward the equator being driven mainly by auroral heating from high energy particles.

Comet or Asteroid

At present, observations seem to slightly favour a cometary origin, though an asteroidal origin cannot yet be ruled out. The answer is not easy to give because comets and asteroids have so much in common: they are small bodies; they are primordial, being formed 4.6 billion years ago along with the planets and their satellites; and either type of object could be expected to be found at Jupiter's distance. The key difference is that comets are largely icy while the asteroids are virtually devoid of ice because they formed much closer to the Sun.

Magellan's Final Orbit

After mapping 98 per cent of Venus' surface since 1990, the Magellan spacecraft, with its solar cells now degraded and running on half-power, was manoeuvred on 11 October on to orbits successively closer to Venus for one last experiment - to gather data on how the spacecraft reacted to Venus' upper atmosphere. Final contact was lost on 12 October with the spacecraft facing disintegration during the following two days.

HST Distance Measurement

Results from the Hubble Space Telescope, reported in *Nature* on 27 October, imply an age for the universe of 8 to 12 billion years which is significantly less than ages previously estimated for the oldest stars in the Milky Way.

The new observations are of Cepheid variables in the spiral galaxy M100 and establish its distance at 56 ($\pm$6) million light-years, being the most distant galaxy in which Cepheid variables have been accurately measured. On combining this value with the observed rate of recession of M100, the expansion rate of the universe is obtained as 80 ($\pm$17) km/sec/megaparsec.

The Hubble astronomers emphasize that more distant galaxies need to be observed before a definite value can be put on the age of the universe as other galaxies could be influencing the rate of expansion of M100.

Spacecraft Join Jupiter Impact Watch

Galileo

During the impacts of the fragments of Comet Shoemaker-Levy 9 on Jupiter between 16 and 22 July the Galileo spacecraft captured an extensive range of data. Because of its position at 240 million km from Jupiter and having the impact sites on the planet's night side in view, Galileo was able to make unique direct observations of the impact events which were not visible from Earth.

The data from Galileo's instruments were stored on the spacecraft's onboard tape recorder and are intended for gradual transmission to Earth between August 1994 and January 1995.

The spacecraft's photopolarimeter-radiometer has already transmitted light-intensity readings from the impacts of comet fragments H, L and Q on Jupiter's far side. The B impact did not produce a significant indication; data from fragment P was recorded on tape for later playback.

Engineering telemetry indicated that Galileo's computer directed the imaging system, the near-infrared spectrometer, the ultraviolet spectrometer and plasma wave instrument to observe the impacts as planned. The camera observed the fragment D, E, K, N, V and W events, the infrared instrument the C, F, G and R impacts.

Ulysses

The Ulysses spacecraft, currently exploring high latitude regions over the Sun's southern pole is in the midst of its primary mission to examine the complex forces at work in these regions of space (see p. 417).

Ulysses was in a position to observe the impacts of comet Shoemaker-Levy 9 during mid-July. At the time Ulysses had a direct line of sight to the impact region being 74.5 degrees south of the Sun's equator. The spacecraft was about 375 million km below the ecliptic plane and 795 million km from Jupiter. Ulysses' unified radio and plasma wave experiment was reconfigured to provide the highest level of sensitivity for detecting very low frequency radio waves of less than 1 MHz that might have been generated by the comet impacts. Data from the impact of fragment A on 16 July to that of fragment Q on 20 July have been processed and analysed, but no clear evidence of changes in radio frequencies has been detected. Jupiter normally has considerable activity at these frequencies. Members of the Ulysses radio science team will continue to watch for the more subtle or long-term effects of the comet collisions, but they do not anticipate much new information in the aftermath of the event.

Voyagers 1 and 2

Voyager 1 is currently 8.4 billion km from Earth and Voyager 2 is 6.4 billion km from Earth. Both are in a healthy state and are continuing to take data on fields and particles in interplanetary space. Voyager 2 used two of its scientific instruments to look at the impacts of Comet Shoemaker-Levy 9 fragments on Jupiter on 16-22 July. Both the ultraviolet spectrometer and the planetary radio astronomy experiments were used in the observations. Neither instrument detected any UV emission or radio signals during the impacts. At the time of the comet impacts, Voyager 2 was 6.1 billion km from Jupiter.

Telescopes for the 21st Century

UK Partners Major Telescope Project

New Technology Promises Clearer Images

On 7 October the construction phase started of the giant GEMINI twin telescopes, to be built in Hawaii and Chile with a ground-breaking ceremony at the site on Mauna Kea, Hawaii which is at 4200 m and is now to be the home of the 8.1 m northern twin of the GEMINI partnership. The Southern Hemisphere telescope was due to be inaugurated in Chile on 22 October at Cero Pachon at 2700 m altitude.

The GEMINI partnership comprises six countries: the United Kingdom, the United States, Canada, Chile, Argentina and Brazil. The UK's 25% share in this technically advanced project is the responsibility of the Particle Physics and Astronomy Research Council and will ensure that UK astronomers will have access to the very best facilities well into the 21st Century. The project is administered by the National Science Foundation of the United States on behalf of the international partnership.

The light gathering power of the huge 8.1 m diameter mirrors, coupled with the superb imaging ability of the optical systems, will make these next generation telescopes ten times more sensitive than existing 4 m telescopes. It is confidently expected that the GEMINI telescopes' power will provide answers to some of the great astronomical questions, such as the origin of planets, stars, the chemical elements, quasars, active galactic nuclei and galaxies. GEMINI will also be used to explore the frontiers of cosmology, where the GEMINI telescopes will enable astronomers to see far back in time to view events shortly after the "Big Bang".

A unique feature of the GEMINI telescopes will be their ability to produce sharp images without needing to be located in space. Normally, the atmosphere blurs astronomical images, producing the familiar twinkling effect which washes out important detail. GEMINI will avoid this by carefully controlling the flow of air around the telescope and by making use of new technology to cancel out this blurring effect. In the infrared GEMINI will provide even clearer images than the refurbished Hubble Space Telescope, but with much greater sensitivity and at a fraction of the cost.

"First light", or inaugural observations, are expected in Hawaii in 1998, with full operation in 2000. The Chilean telescope will see first light in 2000 and become fully operational two years later. Design work for GEMINI began in 1991 and when completed this major international project will have cost some £120 million, shared amongst the partners. ■

Telescopes for the 21st Century

Full Speed Ahead for ESO in Chile

Four Interconnected Telescopes to be Constructed

The European Southern Observatory (ESO), which was founded in 1962, operates 14 optical telescopes with diameters in excess of 3.6 m on La Silla a 2400 m mountain in Chile. A 16 m equivalent Very Large Telescope is under construction in the form of four interconnected 8.2 m mirrors on Paranal mountain in the Chilean Atacama desert.

The construction work on the Paranal site is progressing very well and it is expected that, as planned, the first telescope enclosure will be ready in May 1995 to receive the first 8.2-metre telescope. In early October 1994 the first large shipment containing heavy steel parts of the enclosure left the Italian port of Genoa.

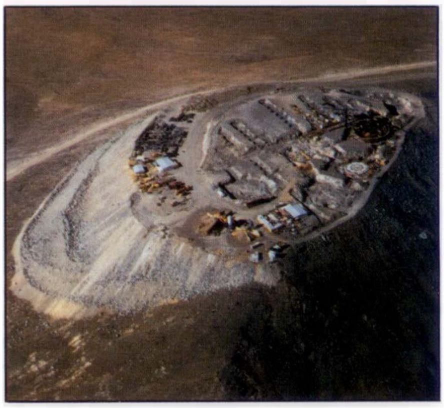
The first 8.2-metre mirror is currently in the middle of a two-year polishing process at the REOSC company near Paris, and the first interferometric tests have shown that this very delicate operation is progressing well. The enormous mirror surface, with a total area of more than 50 m², is slowly but steadily approaching the desired shape which must be achieved within a few hundred-thousandth of one millimetre over the entire surface.

Mirror blank No. 2 is now ready at the Schott factory in Mainz (Germany) and will be delivered by barge transport to REOSC in October 1994. Blank No. 3 has successfully completed the critical ceramization phase and blank No. 4 will soon receive the same treatment.

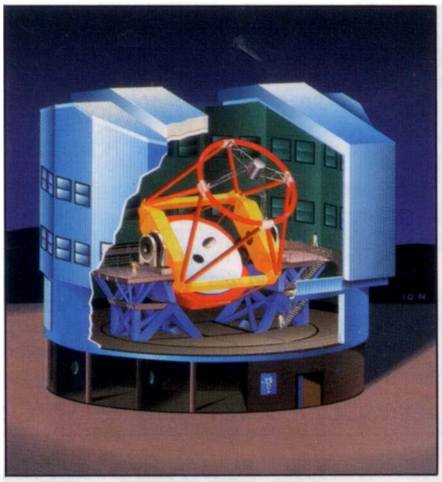
The circular steel track, 18 metres in diameter, that will support Telescope No. 1 has now been successfully machined at the Ansaldo factory in Genoa, Italy. The substructure on which this track and the complete telescope steel structure will be pre-erected before shipment to Chile was constructed at the Ansaldo factory in Milan. Full integration of the first telescope will take place in Milan during the test-assembly phase in the first half of 1995. For the first time it will then be possible to fully appreciate the enormous size of this structure. All structural elements for the enclosure that will protect Telescope No. 1 have now been machined at Idromacchine in Mestre near Venice.

The first shipment of heavy steel parts of the enclosure with a total weight of more than 100 tons is expected to dock in Antofagasta towards the end of November 1994, after which the parts will be transported by truck to the top of Paranal.

This first shipment will soon be followed by others; it is expected that consignments of about 100 tons each will be sent to Chile every two weeks over the next eight months.



Paranal mountain top at 2640 m showing construction work on the four bases of the telescope sites (Mid-September 1994). No. 1 (on the right) has reached "floor level", the basement floor of No. 2 is installed and concrete work will soon start in the holes excavated for Nos. 3 and 4. Other excavations relate to the control building (extreme right) and the various laboratories. ESO



A cut-away artistic drawing of the final telescope assembly. The rotating part of the enclosure (light blue) will turn in unison with the telescope and provide an almost 12 m wide viewing slit. ESO

In the foreground is the basement floor of the No. 2 unit. A passageway (right of centre) which leads to the No. 1 unit, will be concreted over and buried, becoming a connecting tunnel. On final completion only the four domes will be above the surface to reduce wind turbulence that could adversely affect the quality of observations. ESO

About 350 people employed by the construction firm Skanska/Belfi now live in the completed base camp and work in shifts day and night on the mountain. The tunnelling for the many underground passages is finished, the concrete base for Telescope No. 1 is nearing completion, and the baseplate for No. 2 is ready.

The anti-seismic supports to be embedded in the foundations for protection against the strongest earthquakes, have already arrived in Chile and will soon be installed below enclosure No. 1. It is then intended to start the erection of the major parts of this enclosure in mid-December 1994, immediately following the termination of the construction of the concrete support.

This work will start with the assembly of the lower, fixed part of the structure that carries the circular track on which the upper part rotates. It is expected that this will last about six months and that the first enclosure will be ready in May 1995. The erection of enclosure No. 2 will begin immediately afterwards and will be followed by Nos. 3 and 4. This work should be terminated by the end of 1996.

The heavy parts for Telescope No. 1 will arrive at Paranal shortly after May 1995. The lower telescope structures will then be built on top of the two circular tracks and later the telescope tube will be attached at the top. Then follows the installation of the optics, including the 8.2-metre main mirror and the first astronomical instruments.

Then arrives the long-awaited moment when the telescope will open its giant eye towards the Universe for the first time; astronomers refer to this special event as "first light". Finally, the telescope will be thoroughly tested, before it is made generally available to the astronomers. This will probably happen about three years from now, in late 1997. The other three telescopes will be installed during the following years for completion just after year 2000. ■

Ulysses Probes the Sun's South Pole

Early Findings on Solar Wind and Unusual Electromagnetic Waves

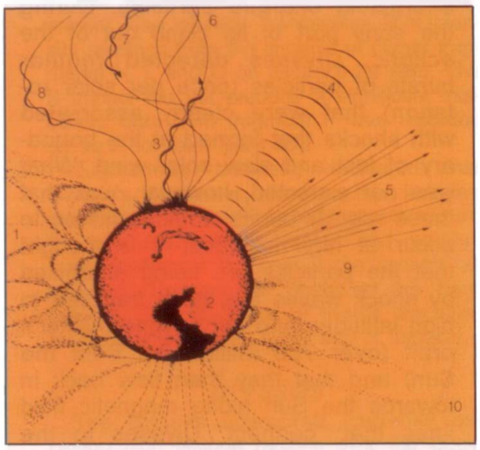
On 13 September 1994, the Ulysses spacecraft reached a solar latitude of 80.2° S. It was then almost over the Sun's south pole, which - along with the north pole - is the probe's main target for exploration. This was the climax of the south polar pass phase, which began on 26 June and ended on 5 November. So far the mission has been a complete success with the probe and its instruments performing perfectly.

Sixty million bits of data are transmitted daily from Ulysses and the information so far accumulated has already yielded major discoveries concerning the Sun's environment at high latitude. In particular, Ulysses has detected: solar wind shock waves at high latitude; very long-period electromagnetic waves (over ten hours); surprising residual activity of energetic particles above the Sun's south pole; and, it would seem, the equally surprising behaviour of energetic cosmic radiation in this region.

The broad aim of the mission is to explore for the first time the overall structure of the Sun's environment from the equator to the poles. The Sun is not in fact the clearly delimited sphere as would appear in the conventional optical images. Beyond its bright gaseous surface is an atmosphere that is 200 times hotter, thousands of millions of times less dense and millions of times less bright. This *corona* can be observed at X-ray and radio wavelengths, and in white light during solar eclipses, and is found to be unstable. As it is too hot to be confined by the Sun's gravity, it evaporates, producing a continuous outflow of ionised gas called the *solar wind*, whose density on reaching the Earth is at most 5 atoms/cm^3 and whose speed fluctuates between 1.5 and 3 million km per hour.

Up until only a few months ago, our knowledge of the corona and the solar wind had been lacking in one important respect. Prior to then, the properties of the solar wind had been measured essentially in only one plane: that of the ecliptic, the plane close to which the planets orbit the Sun. No direct information had therefore been available concerning the solar wind outside that plane. Ulysses has now been out of the ecliptic for two years. In flying over the Sun's south pole this year and north pole next year, it is going to provide an entirely new perspective on the heliosphere, the region surrounding the Sun.

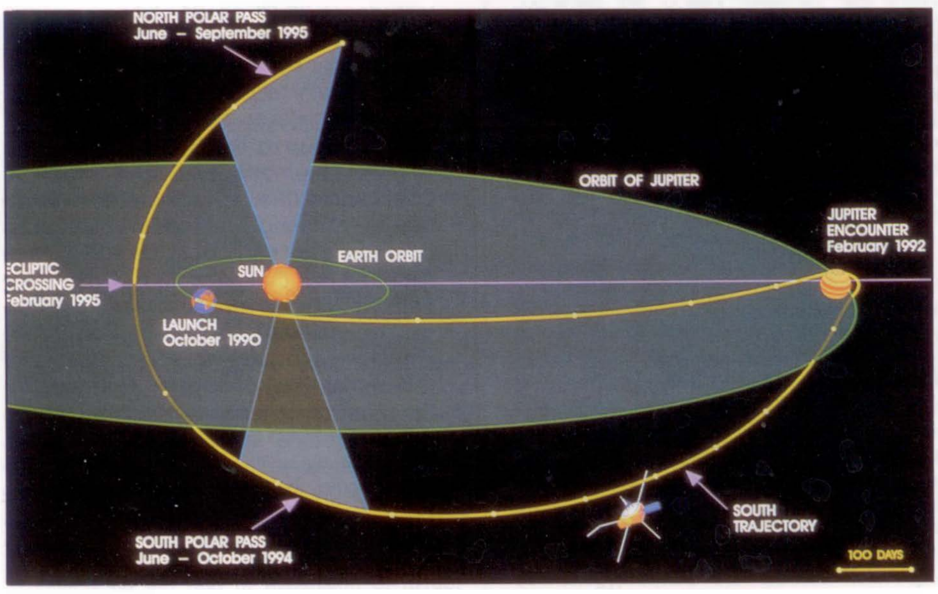
Features of the Solar Environment
Key: 1. Visible Corona; 2. X-Rays, Extreme Ultraviolet; 3. Solar Energetic Particles; 4. Solar Radio Noise; 5. Solar Wind; 6. Solar Interplanetary Magnetic Field; 7. Cosmic Rays; 8. Plasma Wave; 9. Cosmic Dust; 10. Interstellar gas.



Exploring the third dimension of the Solar System is worthwhile on both scientific and practical grounds. From a distance of tens of thousand of kilometres, the solar wind can trigger showers of particles and "magnetic storms" in the terrestrial magnetosphere. Here on the ground, the processes involved can cause interference to radio communications and disruption of power supplies. In space, it can lead to the loss of satellites and even endanger the lives of astronauts. Understanding more about the dynamics of he solar wind would therefore be very useful for explaining these undesirable effects and perhaps anticipating them.

Above: **Ulysses on its way to the thermal vacuum chamber at ESTEC.** **ESA**

Before Ulysses, no spacecraft had ever really left the plane of the ecliptic. Even Pioneer and Voyager, which had journeyed furthest from the Sun in visiting the more distant planets, had only done so to a limited degree. In order to extricate itself from the ecliptic, Ulysses had to undergo a series of powerful accelerations. Launched by the Shuttle Discovery on 6 October 1990, the probe was successively accelerated by its two booster stages to a speed of 43 km/s and then again with the aid of Jupiter's gravitational pull. On 8 February 1992, the gravitational "slingshot" manoeuvre around Jupiter was angled to throw it out of its original orbital plane into a highly inclined orbit for accessing the polar regions of the Sun.



The 3 x 3 x 2 m probe weighs 370 kg and is comparable in size and weight to a small car. It was specifically designed for very sensitive measurement of electrical and magnetic fields by two (7.0 and 7.5 m) antennas and two magnetometers positioned on a 5.5 m deployable arm. All on-board equipment has been designed in order to keep electromagnetic interference to a minimum. Indeed, for a long time to come Ulysses will remain the only

spacecraft providing such a level of "electromagnetic cleanliness".

The scientific core of the system comprises 9 instruments weighing a total of 55 kg. Since the start of the mission, they have been continuously measuring the solar wind, magnetic field, energetic particles and radio and X-ray emissions from the Sun. Taking advantage of the trajectory chosen, they are also measuring the characteristics of the flow of matter (atoms, ions, dust, energetic particles) and gamma radiation, which cross the Solar System and come from the Galaxy or beyond.

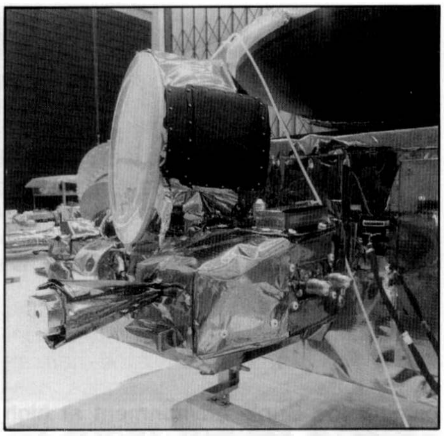
Ulysses is tracked for eight hours every day, when data stored on board during the previous 16 hours are transmitted to Earth together with realtime information. In all, 10 gigabytes of highly valuable scientific information have been gathered in nearly four years - enough to fill 25 CD-ROM format laser compact disks (equivalent to 100 magnetic tapes). Data are distributed to 120 investigators at 47 laboratories in 12 countries in Europe and North America.

Several important observations were made during the climb to high latitudes. The first of these concerns the formation of shock waves in the solar wind away from the ecliptic. The Sun produces two kinds of solar wind travelling at different speeds: the slow solar wind, flowing at 1.5 million km per hour, which we find in the ecliptic, and fast solar wind flowing at nearly twice the speed, which we know to come from coronal holes. When fast wind collides with slower wind ahead, as often happens in the ecliptic, shock waves are formed very much like the shock waves caused by a supersonic aircraft. The new result revealed by the Ulysses measurements is that these shock waves travel to much higher latitudes than was previously expected.

The second - also unexpected - observation concerned periodic increases in the number of energetic particles recorded by the instruments on board Ulysses. From measurements made near the ecliptic, scientists know that shock waves in the solar wind can be very effective in energising charged particles. During the early part of its climb out of the ecliptic, Ulysses detected regular bursts of particles (once per solar rotation) that were clearly associated with shocks that formed at the boundary of fast and slow solar wind. What was not expected, however, was that these regular bursts would continue to occur at high latitudes. It is thought that the particles are being energised by shock waves that have travelled to high latitudes and out beyond Jupiter's orbit (over 700 million km from the Sun) and that they then flow back in towards the Sun along magnetic field lines that "connect" Ulysses to the shocks.

Ulysses' magnetometers detected an unusual kind of slowly varying electromagnetic wave. According to ESA project scientist Richard Marsden:

"These very long-period waves (10-20 hrs) travel along the magnetic field lines, rather like the acoustic vibration of a guitar string."



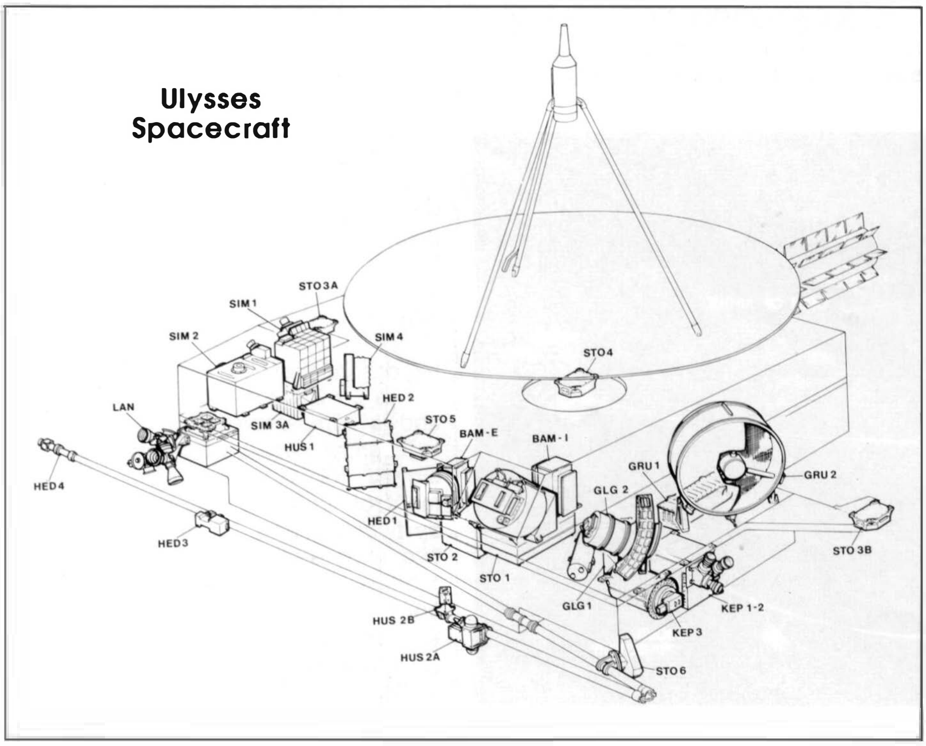
The large drum-shaped sensor of the DUST experiment (Code GRU on the diagram below) with its protective cover in place. The equipment, a part of which was designed by the University of Kent at Canterbury, detects individual dust grains and measures their mass, speed, flight direction and electrical charge. ESA

Lastly, Ulysses has detected several enormous clouds of ionised gas emitted by the Sun. This was the first time that the emission of such clouds - equivalent to a mass of approximately 10 thousand million tonnes and stretching over 50 million km - had been directly observed (in situ) at high solar latitudes. Coronal mass ejections (CMEs) are a well-known phenomenon in the ecliptic plane, where they are the prime cause of polar auroras and magnetic storms. Studying them at high latitudes, under particularly favourable conditions, will improve our understanding of how they come into being and evolve - and perhaps also enable us to better anticipate their disrupting effect on technological activities on Earth.

This first high-latitude pass will be followed in 1995 by a pass over the north pole. This will take place from 20 June to 30 September, with the satellite reaching its maximum northerly latitude of 80.2° on 31 July.

Lastly, Ulysses' epic journey will not necessarily be ending in October 1995 as nominally scheduled. In any event, after that date, the spacecraft will continue to orbit the Sun and will again fly over the north and south poles in 2000 and 2001. It is therefore tempting to envisage extending scientific operations to early next century, especially as by that time the Sun's magnetic activity will be at its peak - a splendid opportunity to conduct a three-dimensional study of solar flares and the emissions of matter that disturb the Earth's environment. Discussions are therefore underway with NASA with a view to continuing the mission accordingly. ESA, for its part, has already approved the plan, subject to US participation, which is technically essential. ■

Positioning of experiments. Codes: BAM - Solar-Wind Plasma Experiment; GLG - Solar-Wind Ion Composition Spectrometer; GRU - Cosmic Dust Experiment; HED - Magnetic Field Flux-Gate/Vector Helium Magnetometers; HUS - Solar X-rays/Cosmic Gamma Ray Bursts Hurley-Sommer Experiment; KEP - Energetic-Particle Composition and Neutral Gas experiment; LAN - Low-Energy Ions and Electrons; SIM - Cosmic Ray and Solar Charged Particle Investigation; STO - Unified Radio and Plasma Wave Experiment. ESA



ISU '94

BY JORGE MUNNSHE
Barcelona, Spain

The 1994 Summer Session of the ISU (International Space University) was held at the Autonomous University of Barcelona (UAB), Spain, from June 27 to September 2. Many well-known scientists took part in it as Faculty Members and Visiting Lecturers.

ISU '94 participants.

Fields of Study

Ten Faculties comprise the several space specialities, both those with an established educational tradition and those that have only recently appeared: Space Systems Architecture and Mission Design; Space Business and Management; Space Engineering; Space Life Sciences; Space Policy and Law; Space Resources, Robotics and Manufacturing; Satellite Applications; Space Physical Sciences; Space Humanities; Space Informatics.

During the summer sessions, all the alumni attend a core lecture series plus a specialized lecture series provided by each academic department.

Besides these summer sessions at different locations, ISU will offer, from 1995 on, a Master of Space Studies Program. To this end, an international net of permanent campuses has been created. The central campus is located in Strasbourg, and the others in several countries. The programme will consist of a one-year graduate level syllabus, common to all students, after which there will be several complementary programmes aimed at specialization from which the student will be able to choose. The first level will take place in Strasbourg; and the specialized studies will be held in the affiliate campuses. The first academic year of such courses will begin in 1995-96 in Strasbourg.

Prospective ISU alumni must have good academic qualifications or professional experience in the space field. Access is limited and therefore candidates are selected according to their academic excellence. Because of the high cost of fees (US$ 12,000 was the cost of 1994 Summer Session), ISU advises selected students to apply for scholarships or grants from the academic institutions in their respective countries, with ISU backing to that end. On the other hand, ISU offers scholarships as well, although their number is limited and can be offered only to an elite of highly qualified students.

Russian cosmonaut Oleg Atkov at ISU '94.

ISU Staff and Resources

On the ISU Board of Advisors we find Arthur C. Clarke, Daniel Goldin (NASA), Jean Marie Luton (ESA) and Roald Sagdeyev. Partaking on the Board of Institutional Trustees are the United Nations Office of Outer Space Affairs, NASA, ESA, the space agencies of France, Canada, Germany, and other organizations. On the Board of Industrial and Corporate Trustees, are Matra Marconi Space, Lockheed (now in the process of merger with Martin Marietta), Shimizu, and others.

Most of the lecturers and Faculty Members have active roles in their respective fields, rather than being devoted to teaching only. A number of them are permanent staff of the different Faculties, whereas the others are Visiting Faculty Members or Visiting Lecturers.

More than forty Faculty members tutored the students in ISU '94. Many of them are well-known specialists at an international level. These included astronauts Oleg Atkov and Jeffrey Hoffman; the micro-robotics expert David Miller, who developed planetary micro-rovers for the Mesur/Pathfinder project for NASA; Mikhail Marov from the Keldish Institute of Applied Mathematics, who was involved with the Soviet race to the Moon as well as missions to Mars and Venus; James Burke, retired senior member of the technical staff at JPL; Wendell Mendell from the NASA Solar System Exploration Division; Giovanni Fazio from the Smithsonian Astrophysical Observatory and other institutions, who has developed several scientific instruments for astrophysical satellites as well as being involved in research for several NASA astronomical satellites; Ichiro Nakatani, project manager of the mission Planet-B; Gregg Maryniak from the Space Studies Institute; James Green from the NASA Goddard Space Centre; Brand Griffin, founder of Griffin Design, who was responsible for the technology staff at Boeing as well as for planetary rovers and was a former habitation element manager for the USS Space Station.

Some of the most well-known visiting lecturers were the astronauts Jim Newman and Michael Clifford, Colonels Pedro Rustan and Pete Worden (Clementine Project), Randi Wessen (Manager Science Planning & Operations, Cassini Project), besides other scientists from NASA, MIT, ESA, Tokyo Institute of Technology, Max Planck Institute (Germany), US Air Force Academy and the Moscow Avia-

About the ISU

ISU was founded by Peter Diamandis, Bob Richards and Todd Hawley in 1987. Their goal was to gather into one multi-disciplinary university the whole of space sciences. As university students they had experienced the scattering of space specialities over different departments at several different universities, as well as the scarcity, or virtual non-existence, of educational institutions where access to many of the newest of such space specialities were available.

ISU was designed, as a first stage, to be an itinerant university with intensive summer sessions. The first summer session was held at the Massachusetts Institute of Technology in 1988. The following sessions took place at the Louis Pasteur University in Strasbourg, France (1989), at York University and the Institute For Space and Terrestrial Studies, both in Toronto, Canada (1990), at the Ecole Nationale de l'Aviation Civile, and at the Formation Internationale Aéronautique et Spatiale, both in Tolouse, France (1991), at the Japanese city Kitakyushu (1992), at Alabama University, Huntsville, USA (1993), and at the Autonomous Barcelona University (1994). Up to now, about 800 alumni from more than 50 countries have studied at ISU.

Apollo 11 astronaut Buzz Aldrin (centre) holds a press conference at ISU.

tion Institute.

ISU will have access, if everything works as planned, to an operational satellite to be used in tele-education and tele-medicine experiments and demonstrations, as well as for e-mail exchange between the ISU central campus in Strasbourg and the affiliate campuses all over the world. ISUSAT has been donated by CTA Corporation, a company where Peter Diamandis, one of the founders of ISU, is Director of Commercial Space Programs. ISU will be able to use almost all the satellite's capacity most of the time, although CTA and other organizations will connect with the satellite in order to carry out special tests. CTA will be responsible for Command, Tracking, Monitoring and Telemetry of the satellite. ISUSAT is expected to be launched in 1995.

Major Events

The fact that ISU '94 was held in Spain is mainly due to the initiative shown by a former ISU alumnus, ESA engineer Juan de Dalmau, who organised a Spanish delegation of university top people as well as scientists that visited ISU in Toulouse in 1991. Later, three universities from Barcelona and the Catalan Foundation For Research presented a combined candidature to ISU to become one of the ISU permanent affiliate campuses. The Autonomous University of Barcelona also presented an independent candidature in order to host ISU '94. Both candidates were chosen.

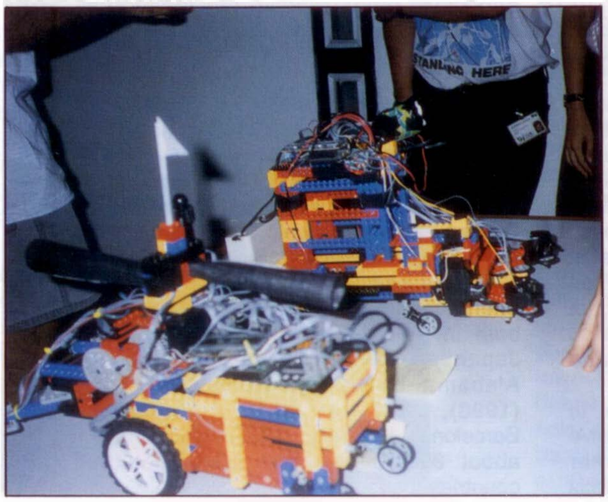
ISU '94 hosted 126 alumni from 29 countries. The nations with a greater presence (more that ten alumni each) were USA, Spain, France and Canada. Nations with five to nine alumni were Italy, Germany, Japan, Sweden and the United Kingdom. From each of the other countries came between one and four alumni.

The most attended Academic Department was Space Engineering, with 33 alumni. The other Departments had a much lower attendance, in the following order: Space Physical Sciences (19); Satellite Applications (17); Space Policy and Law (13); Space Business and Management (11); Space Life Sciences (10); Space Architecture and Mission Design (10); Space Resources, Robotics and Manufacturing (9); Space Humanities (4). The Department of Space Informatics programme was very short and was included in the first core lecture series, common for all alumni.

The core lecture series took place during July, and the specialized lecture series were held during August. The alumni also carried out team work while developing their two Design Projects, besides having other tasks assigned either individually or collectively. Apart from the purely academic activities, there were several open sessions for the general public, all of them of great interest.

The Opening Ceremony was held on June 27. Because of the 25th anniversary of the first lunar human landing, Apollo-11 astronaut Buzz Aldrin attended this ceremony and gave an address. Prior to that he held a press conference. On June 28 spacesuit designer Richard C. Wilde shared a panel discussion with Russian cosmonaut Oleg Atkov and NASA astronauts Michael Clifford and Jeffrey Hoffman, about the differences between the design concepts of the US and Russian spacesuits, and their implications for each country's space programme.

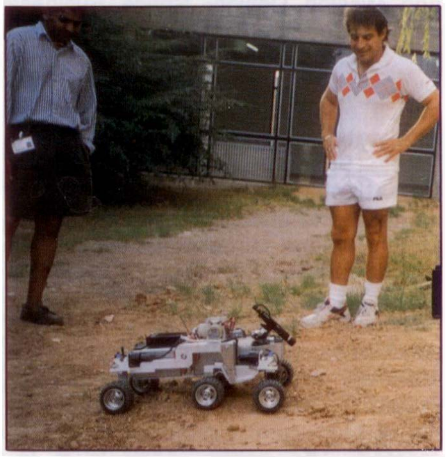
Students participate in a micro-rover building contest.



On June 29, astronaut Jeffrey Hoffman explained in a detailed way his experiences while repairing the Hubble Space Telescope and how this mission demonstrated the feasibility of carrying out complex engineering work in space by means of extra-vehicular activity.

On July 6, Deputy Manager of the NASDA Space Transportation Systems Division, Eiji Sogame, explained the most important aspects in the development of the H-2 launcher and its main characteristics.

On July 9 at dawn (Spanish time) ISU arranged a live high-resolution video-link via satellite to the ESA Space Centre in Kourou, French Guiana to cover an Ariane-4 launch. The launch was a success and cocktails were served to celebrate.

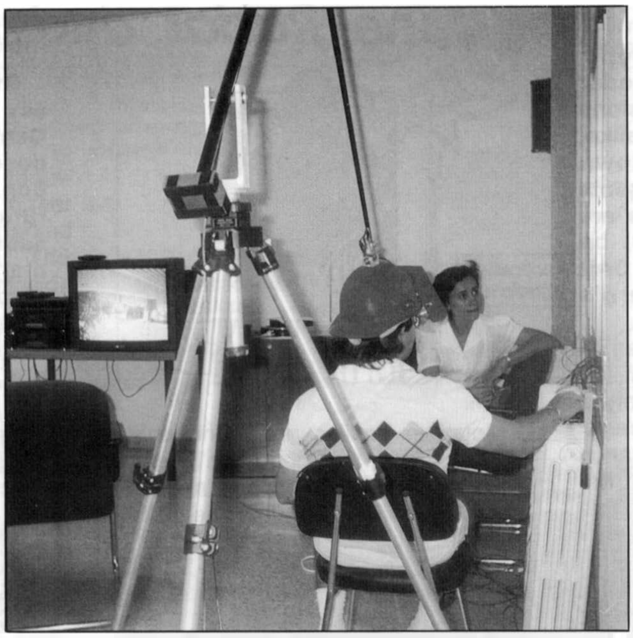


A NASA autonomous micro-rover prototype designed for Mars exploration is activated on rough terrain by NASA engineer Rajiv Desai.

On July 13, former Head of the ESA European Astronaut Centre, Andres Ripoll, and astronauts Jeffrey Hoffman and Oleg Atkov, talked about human space travel, its role versus unmanned missions, its usefulness, the technological efforts made in this regard, and the most important factors in this field.

On July 20, during the Shoemaker-Levy cometary collision with Jupiter, an international tele-conference of astrophysicists and cometary astronomers around the world was arranged. From their respective nations, the scientists exchanged the latest information and advanced some preliminary conclusions. Giovanni Fazio and Mikhail Marov handled the tele-conference from ISU in Spain. Among the participants were: Brian Marsden (the astronomer who researched the comet's orbit and determined that it would lead to a collision with Jupiter), William O'Neill (Project Manager of the Galileo probe), Patrick Moore (renowned British

science advocate and public figure specializing in space issues), Mal Neidner (Deputy Science Director, Hubble Space Telescope), David Hughes (cometary astronomer, Sheffield University), and others. During the tele-conference photographs of the impacts and computer simulations of the trajectories and collisions of the different cometary fragments were shown.

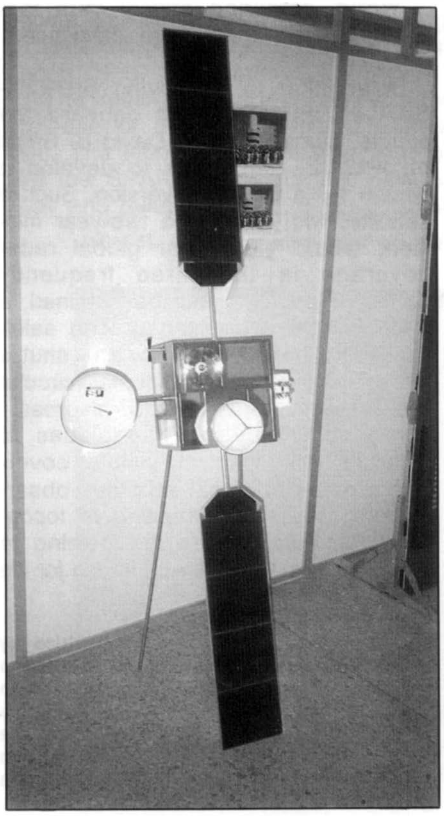


Gilles Primeau operates a micro-rover by tele-presence while wearing a helmet with glasses where the images received by the rover are projected.

On August 3, US Colonels Pete Worden and Pedro Rustan, top officers in the Clementine program, showed different images taken by Clementine, as well as photos and films about high technology space projects in which US DoD has been working. They commented on different aspects in the development of the Clementine project, their conclusions about the results of the mission, and their viewpoints regarding the "cheaper, faster, better" approach to Solar System exploration.

On August 5, the Third Annual ISU Alumni Conference was held. All day long, some ISU ex-alumni presented their current activities in scientific research or the development of technical projects. Some of the presentations were: GEOWARN Project, by Angelia Buckley; High Antenna Gain on the EOS-AM spacecraft, by Danny St.Pierre; Ariane 5 launch operations, by Juan de Dalmau; Mars Observer Replacement Fleet, by Ralf Huber; The SUNSAT micro-satellite, by Sias Mostert; Sciamachy, a spectometer for the ENVISAT to study marine biology, by François Spiero; and others.

ISUSAT mock-up.



On August 8, Randi Wessen (Manager Science Planning & Operations, Cassini Project) offered a summary on interplanetary exploration, illustrating his lecture with spectacular images, while he explained the benefits of Solar System exploration.

On August 11, Alvaro Azcarraga, President of the International Astronautical Federation, lectured on the prospects for global cooperation in space, and compared the various national and international space policies.

On August 12, a series of demonstrations of planetary robotic microrovers was held. On rough terrain, Rajiv Desai, a NASA engineer, activated an autonomous micro-rover prototype designed for Mars exploration. This six-wheeled robot, able to see by means of its camera, was operative for a long time, overcoming such obstacles as big rocks caterpillar-wise. It was also able to stop going forward when faced with markedly uneven ground as occurred for instance when it tried to climb the legs of people in its way. Another microrover, a prototype by the Canadian company Aerocorp Technologies and controlled by means of tele-presence, was also tested. Gilles Primeau, president of that company, operated the robot from a room near the test site. In order to do this, he wore a helmet with glasses where the images received by the robot were projected. After these two demonstrations, a micro-rover contest took place on a specially prepared indoor track using protoypes built by David Miller's students, who had been provided with the same amount of time and materials. The objective of this competition was to create micro-robots able to detect and transport water to a given site.

On August 18, astronaut Jim Newman, first ex-alumnus of ISU to fly in space, explained his experiences, specially the less known aspects of everyday life in space, "the things they don't tell you" about training and space flight.

On August 31, the final presentation of one of the two space projects by the alumni took place: the Solar System Exploration Project, directed by professors Jim Burke and Ichiro Nakatani.

On September 1, the other alumni space project was presented: the Global Tele-Education and Tele-Medicine System, directed by the professors Ram Jakhu and Joe Pelton.

Last but not least, on September 2, the ISU '94 Closing Ceremony was held with the issuing of the hard-earned Diplomas to the students. Different personalities involved with ISU '94 gave their closing speeches and a message from Arthur C. Clarke was also read.

All photos are supplied by the author.

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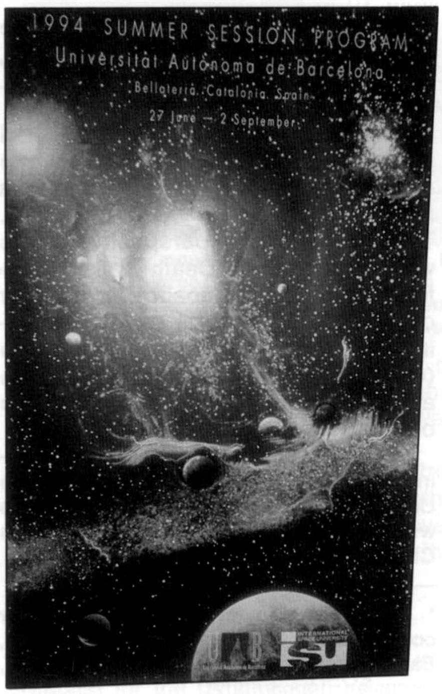
Acknowledgement
My acknowledgement to Montse Andreu for her assistance in the preparation of this report and with its translation.

ISU '94 poster.



About the Radar

New ways of looking at the world, such as Synthetic Aperture Radar (SAR), produce exciting occasions for researcher and onlooker alike. Although SARs have been flown before*, the technology represents a major capability and its uses are still unfolding. (Cassini, to be launched in 1997, will carry a SAR to pierce the clouds of Saturn's satellite Titan.)

The flight system (which resides in the shuttle's bay) was described in the March 1993 *Space at JPL*, so only a brief summary will be provided here.

The SIR-C instrument ("SIR" stands for "shuttle imaging radar" and "C" denotes the third shuttle flight of this category of instrument) was built by JPL and the Ball Communication Systems Division for NASA. It weighs in at a massive 10,500 kg - it proved cheaper not to miniaturize it since the flight would use the full-shuttle capabilities - and utilizes two radar frequencies: L-band (23 cm wavelength) and C-band (6 cm). The instrument can be pointed electronically, without mechanical motion, and, also, is orientable through roll and yaw manoeuvres of the shuttle.

The X-SAR instrument (X-band has a wavelength of 3 cm) was built by Dornier and Alenia Spazio for the German Space Agency (DARA) and the Italian Space Agency (ASI). The antenna is moved mechanically to align the X-band beam with the L and C-band beams.

The SIR-C and X-SAR facilities can be operated independently or as a unit. In combined operation, the instrument is the most powerful radar ever put in space by a civil programme. Ground swaths range from 15 to 90 kilometres and the resolution varies from 10 to 200 meters.

SIR-C/X-SAR was launched on the space shuttle Endeavour on April 9, 1994 for 11 days of flight operations. The electronic net was cast widely.

For example, snow/ice classified maps were made for Ötztal (Austria) and Mammoth (California) as well as a map of flooding at Manaus, Brazil. Three-dimensional perspective views were achieved for Death Valley (California) and the Galapagos and colour composites for several regions including Hawaii and Oberpfaffenhofen (Germany). Land-use classification and vegetation biomass maps were obtained for Raco, Michigan.

Targets of opportunity included flooding in Germany and the Midwestern United States, and tropical cyclone Odille was observed in the Pacific Ocean. In China, panda reserves were targeted.

* For example, on Seasat (1978, for oceanography), the shuttle (1981 and 1983, Earth science), and Magellan (1990-1992, Venusian topography).

The Radar and the Gorillas

The Dian Fossey
Gorilla Fund
Charity No. 801160

Mountain gorillas are found only in Central Africa, and none has ever survived in captivity. There are about 320 of these animals living in the Virunga Volcano region on the border of Rwanda and Zaire. Also, 300 gorillas are located in the impenetrable Forest in Uganda.

Gorillas are vegetarians and are social animals who form groups of up to 40 members. The group is led by a dominant male known as a "silverback." These animals are susceptible to human viruses; flu and measles can kill gorillas.

BY DR W.I. McLAUGHLIN
Jet Propulsion Laboratory
California, USA

I became aware of the need for imaging the habitats of the mountain gorillas with SIR-C/X-SAR, upon receiving, prior to the April flight, calls from Arthur C. Clarke in Sri Lanka and Greg Cummings (UK Director of The Dian Fossey Gorilla Fund) in England. They wanted to have sequences included in the mission plan to accomplish this goal. Indeed, the SIR-C/X-SAR team responded and included the images of Central Africa on a non-interference basis with the primary mission. (My role proved peripheral. I mention it only to indicate how, literally, I became aware of the developing drama.)

The radar imaging was needed because some areas in the habitats of the gorillas have never been mapped before with accuracy. Other areas have not been mapped since the 1950s. The chronic cloud cover of the region made the cloud-piercing services of radar particularly valuable. Use of airplanes for mapping would have been difficult or impossible due to the armed hostilities.

A goal of the researchers is to understand why gorillas live in some regions and not in others. The database being developed (at the Remote Sensing Center at Rutgers University in New Jersey) from the SIR-C/X-SAR observations will further this objective as well as helping to monitor the effects of human encroachment.

In an information letter circulated after the April flight, Cummings summarized the effort. I present two extracts.

1. "My co-director, Jillian Miller, and I have just returned from Kennedy Space Center where we met Arthur C. Clarke. We were all there to witness the launch of STS-68 and the second Space Radar Laboratory mission on 30 September and promote the shuttle's planned radar imaging of the mountain gorillas' central African habitat. Dr. Clarke also agreed to participate in a launch-day press conference to champion the practical applications of NASA's space programme to wildlife conservation."

2. It is a sobering thought - as well as a bold testimony to the space programme - that, while our top primatologists and conservationists were boarding evacuation flights in Burundi, the space shuttle Endeavour was orbiting 120 miles above the last 650 mountain gorillas in the world, acquiring critical data that could save them from extinction."

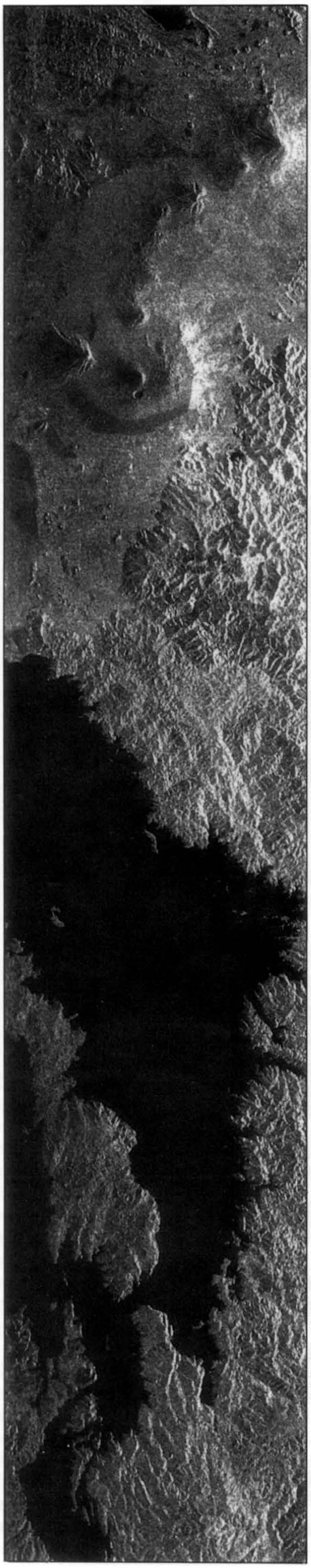
Over 25 years ago, Dr. Dian Fossey founded the Karisoke Research Centre in Rwanda for the dual purposes of gorilla study and protection. Today, the Dian Fossey Gorilla fund, through the Karisoke Research Centre, is the world's primary focus for mountain gorilla research, conservation, and education. (Address: The Dian Fossey Gorilla Fund, 110 Gloucester Avenue, London NW1 8JA, England)

In addition to employing SIR-C/X-SAR as an instrument onboard the shuttle, studies, led by David B. Smith of JPL, are underway to develop a design for a free-flyer version. Such a satellite, with at least a two-year mission, would yield near global radar coverage in the three frequency bands. If approval can be obtained, a 1998 launch is envisaged. The satellite would be launched by the shuttle into a 400-kilometre altitude, circular orbit at an inclination of 57 degrees.

Missions with the capabilities to perform multispectral visible coverage, meteorological-satellite observations, and radar mapping of topography and vegetation are helping to make good the promise of space for life on Earth.

See right: **This image of Central Africa by SIR-C/X-SAR shows the Virunga Volcano chain. It was acquired on 12 April 1994 on orbit 58 of the shuttle Endeavour. The image covers an area 58 km by 178 km. The dark area is Lake Kivu. The region shown here is home to endangered mountain gorillas.** NASA/JPL

Gorilla Territory Viewed from STS-59



TOPEX/POSEIDON Maps the Oceans

On August 10, 1994, TOPEX/POSEIDON, the ocean topography experiment, celebrated two years of successful flight operations. This is a project that has everything going for it: first-rate science with its investigation of the circulation patterns of Earth's oceans; an exemplary international collaboration between NASA and the French space agency, CNES; establishment of new engineering standards for altimetry from space. The ramifications of TOPEX/POSEIDON are so vast for the understanding of one of Earth's dominant features, its watery envelope, that it will take years to appreciate the results. But I felt it was now appropriate to acquire a snapshot of the status, and the Project Manager, Charles A. Yamarone, was kind enough to spend some time with me.

Yamarone entered the business of space oceanography in 1977 when he joined JPL's Seasat Project as the Information System Manager. Seasat was a multi-instrumented satellite - altimeter, synthetic aperture radar, etc. - which was launched in 1978 and failed after 78 days in orbit, probably due to an electrical short circuit.

After the failure, funds which had been marked for mission operations were reprogrammed for use in analyzing the data that the satellite did acquire. The analyses were very successful and the project achieved more than 90% of its objectives despite the early failure. Indeed, Seasat, which was designed to be a "proof of concept" mission, has not only excelled scientifically but has also served as progenitor for other missions, including TOPEX/POSEIDON.

The preproject work for the "Ocean Topography Experiment" (TOPEX) was assigned to JPL in 1980 with Yamarone as project manager. The goal was to get a new start for the project in 1982. ("New start" is that Darwinian event wherein the US Congress designates a preproject as one that has been selected to be carried to completion.) Yamarone said that TOPEX came close but did not achieve new-start status and entered a queue. In 1983, CNES joined with NASA in this endeavour and "TOPEX/POSEIDON" was initiated. The project arrived at the top of the queue in 1986 but did not actually get a new start until 1987.

There are six scientific instruments onboard TOPEX/POSEIDON (see the December 1991 and October 1993 issues of this column for a more detailed description of the satellite and mission): four from NASA and two from CNES. The principal instrument is the NASA dual frequency altimeter. Two frequencies (5.3 and 13.6 GHz) are employed in order to obtain greater precision through measuring and correcting for free electrons in the ionosphere.

The microwave radiometer (NASA), allows measurement of another error source, water vapour in the atmosphere. The two remaining operational sensors are an array of laser retroreflectors (NASA) and the DORIS Doppler tracking system receiver of CNES.

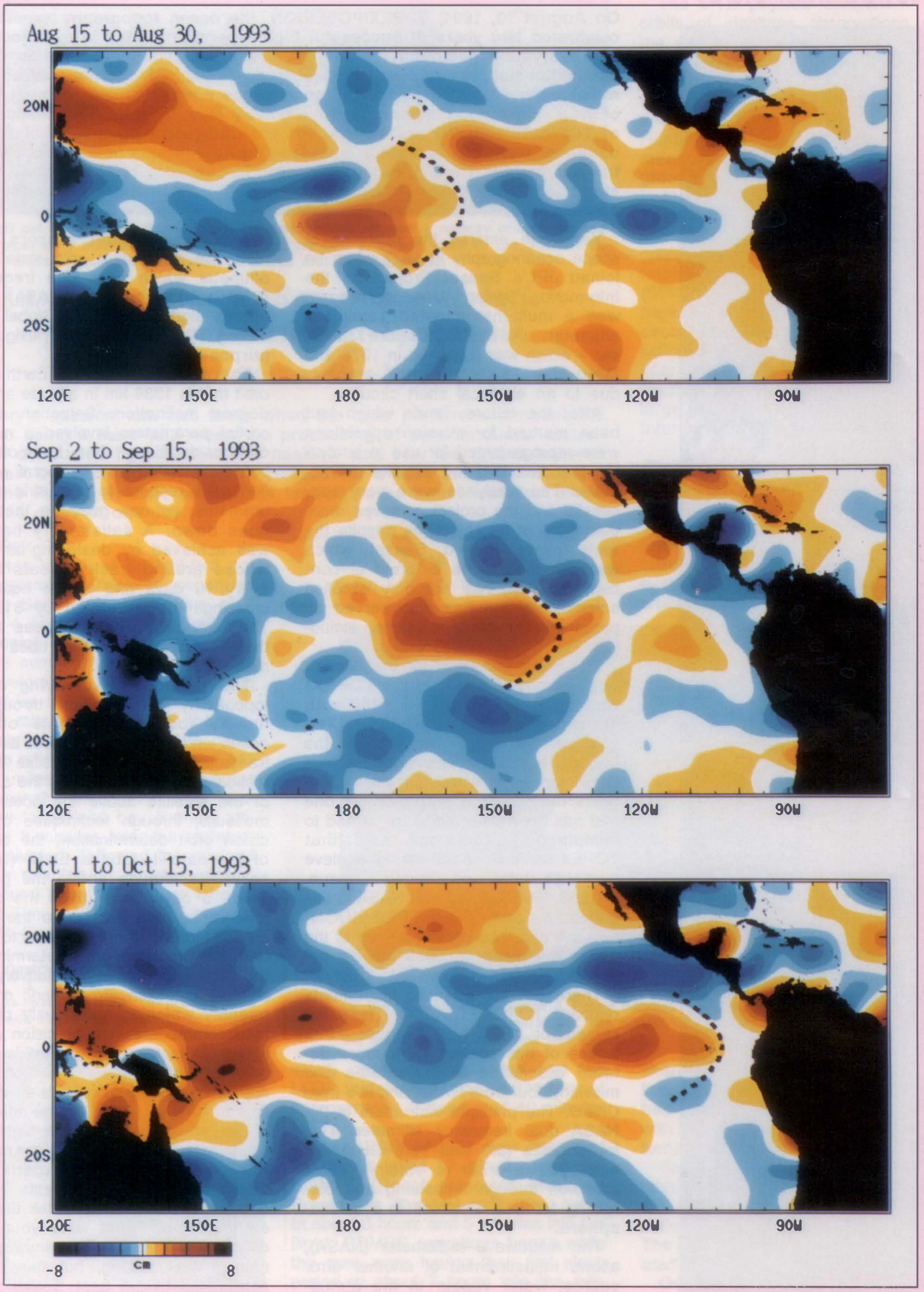
Two experimental sensors complete the payload: a solid-state radar altimeter which uses one frequency (CNES) and a receiver (NASA) which utilizes signals from the Global Positioning System (GPS) for navigational purposes.

The satellite circles the Earth in an orbit that is 1336 km in altitude and 66-degree inclination. Selection of the orbital parameters involved a number of considerations. One trade-off was between spatial and temporal resolution with respect to altimetric measurements; as one goes up the other goes down. A satisfactory balance was achieved by designing an orbit whose ground track repeats about every 10 days and whose equatorial crossings are separated by 315 km. The inclination of 66 degrees allows the first measurement of tides to be made from space.

The method of surveying ocean topography is to measure through altimetry (bouncing signals off the ocean and timing the interval between transmission from the satellite to detection of the return signal) the altitude of the satellite above the ocean and measure, through techniques of precision orbit determination, the altitude of the satellite above Earth (technically: the altitude above the geoid). Then, a calculation gives the ocean topography with respect to the Earth as a reference frame. In order to facilitate the precision orbit determination, the orbit was put at a relatively high altitude to lessen atmospheric drag (a quantity which is notoriously difficult to accommodate in a precision analysis) and the vagaries of Earth's gravitational field. However, the orbit could not be so high as to require an unrealistic amount of power for the altimeter.

Like an astronaut after a flight or a postwar general, project managers have had significant experiences. One of my favourite moments in conducting an interview is to ask the project manager, "what were your most difficult challenges?" The answers are usually not startling, but they represent some of the best distillations of experience that can be obtained in our profession.

At the top of Yamarone's list was working with the contractor (Fairchild) to get the spacecraft built and tested.



This is a three-panel image processed by the Naval Research Laboratory using data from the U.S./French TOPEX/POSEIDON satellite. It shows the eastward movement of a "Kelvin wave" along the equatorial Pacific Ocean. A Kelvin wave is a rise in sea surface caused by relaxation of winds over the western Pacific. This wave began in early August 1993 and moved eastward in a bulge of sea-surface elevation of 10-15 cm above normal.

It was not the challenge of new technology - the spacecraft was based upon NASA's Multimission Spacecraft (MMS) - but rather the day-to-day activities.

Second on his list came readying of the ground system for flight operations. (Before launch I was a technical section manager supporting development of parts of this system for TOPEX/POSEIDON and can attest to the difficulties.) A basic problem with this kind of mission is, as Yamarone said, "we launch into encounter." Here, "encounter" is an allusion to that event in a JPL planetary mission where, after an interplanetary-cruise phase, we arrive at the planet and intensive operations begin. With TOPEX/POSEIDON, there was no luxury of a cruise phase to shakeout the ground system and get comfortable with the behaviourial characteristics of the flight system. In addition, the ground system was designed to use NASA's Tracking and Data Relay Satellite System (TDRSS) rather than the Deep Space Network (DSN) used for most JPL missions; i.e., a learning curve had to be traversed.

Both of the subjects of these top two challenges have functioned well after launch. For the flight system, only two anomalies have been experienced. For the first two months, the pointing error of the boresight had been too large. Calibrations of the system and corrections to the flight software have rectified the problem; the error is now about 0.05 degrees per day, which is even better than required. The second anomaly occurred on November 25, 1993 when one of the satellite's two star trackers failed, probably due to radiation damage (a "single event upset"). The remaining star tracker is adequate with respect to attitude-control functions and so no attempt has yet been made to revive the failed tracker.

The second challenge, the ground system, has been met for control of the satellite and the acquisition and distribution of data products. In fact, the data products are being analyzed by a worldwide team of about 200 scientists who are investigating global ocean dynamics, ocean tides, marine geophysics, and geodesy. The basis of these data is global sea-level measurements accurate to better than 5 cm: not bad when you consider the requirement was 13 cm.

It might have been expected, a priori, that the international interface, between NASA and CNES, would be a major challenge. However, Yamarone said that the experience with CNES has been very good from the start. A detailed memorandum of understanding (MOU) between the two agencies saved time during development because issues of procedure did not have to be solved while engineering problems pressed.

The experience with the Ariane 42P launch vehicle was also positive. Close collaboration between the project and the launch-vehicle team was necessary in order to produce a careful test plan for the satellite that would insure it would survive the stresses of launch unharmed but, also, not be damaged by overly vigorous testing.

A summary of some of the scientific results from TOPEX/POSEIDON is scheduled for the December 1994 issue of the *Journal of Geophysical Research*.

The baseline mission has been planned to be three years of operations, and an extended mission of another three years is desired by the project. The success of TOPEX/POSEIDON has led to discussions between NASA and CNES for a follow-on mission. If all goes well, a launch would take place in 1999, continuing the oceanographic legacy of Seasat and TOPEX/POSEIDON.

In Praise of Monte Carlo

Links between gambling and mathematics were established long ago by Gerolamo Cardano (1501-1576) and Blaise Pascal (1623-1662). The services of mathematics to the art of gaming continue to this day through the analyses of authors such as Peter Griffin and Edward Thorp in the advantages that can be obtained in the dependent series of trials which constitute the game of blackjack. In the other direction, the inspiration to mathematics provided by gambling did not dry up in the Renaissance; in the years after World War II, the mathematicians John Von Neumann (1903-1957) and Stanislaw Ulam (1909-1984) created the "Monte Carlo method," a mathematical technique which proceeds through the use of probabilistic simulation.

My experiences with Monte Carlo approaches in space missions have convinced me of the utility of the method. Also, there are, I believe, virtues in the conception that go beyond technical values alone. In a very broad sense, Monte Carlo techniques supplant time-honored methods of augury such as the Roman practice of carrying chickens into the field with an army and deducing military prospects from observing how these birds ate their grain. (The modern approach is also less messy.)

There are many good expositions on the theory and practice of Monte Carlo, and it is not my intention to examine these topics in any depth. However, it is necessary to have a common understanding of what constitutes "Monte Carlo." "Random numbers" are interesting in themselves and are a good place to start.

There is an old joke about reading the dictionary and complaining that it lacks a plot. Some years ago I began reading tables of random numbers, an activity which might be thought flawed in a similar manner. A table of a million random digits published by the RAND Corporation was an early classic that I have particularly enjoyed.

Let me give you some of the plot line: 29582, 24994, 60983, 65525. Presented in this way, the digits seem rather unrandom, but, in a large set, patterns appear. Thus, the first lesson about random numbers is that they will look ordinary only in the long run. This lesson, of course, extends to a broader field of activity: ever had a bad day?

There is no short, effective definition of "random." Usually, numbers are tested for randomness by subjecting them to statistical tests which the user feels relevant. For example, a set of random decimal digits should have an average which is close to 4.5.

More generally, a sequence of random numbers is characterized by the property that no member can be predicted by knowledge of those that precede it. The statistical and the predictive criteria relate curiously to one another, e.g., the digits of pi appear to be random under statistical examination.

From a practical point of view the generation of random numbers is not an easy task. Two general methods are employed: the use of algorithms, usually implemented on a digital computer, and the numerical interpretation of certain physical processes. Numbers produced by the first method are called pseudo-random numbers and a great deal of research has gone into devising algorithms that are efficient and yield high-quality numbers. Pseudo-random numbers have the limitation that they will eventually repeat but have the merit of being reproducible, a desirable feature in any experimental situation, numerical or otherwise.

The introduction provided for the RAND table makes as good reading as the table itself. (If you are now determined to get this classic, it is: *A Million Random Digits with 100,000 Normal Deviates*, by the RAND Corporation, The Free Press, New York and Collier-Macmillan, Ltd., London, 1955. That part about "normal deviates" belongs in any good collection of oxymorons.) The struggle to get the "electronic roulette wheel," which generated one number per second, to produce random-looking numbers required occasional tuneups of the device. After it had been run too long, its personality started to assert itself and the num-

bers departed from random. On the plus side, the final tables did not have to be proofread!

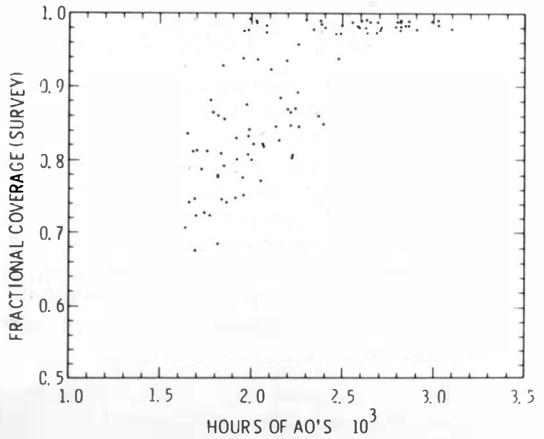
A simple use of random numbers in a Monte Carlo situation is the estimation of the area contained inside a plane geometric figure. Enclose the figure inside a square - frame it - which measures one unit on a side. Pick two of the intersecting sides of the square as coordinate axes. Then select a pair of random numbers, each lying between zero and one, and place them separately on the coordinate axes; a point, with its two coordinates equal to the two random numbers and lying in the square, has been created. Proceed in this fashion creating many random points within the square. (The process is akin to throwing darts randomly within the square.) The area of the geometric figure is just the fraction of the random points which fall inside it.

My principal professional use of the Monte Carlo technique was to address a question concerning the Infrared Astronomical Satellite (IRAS). This Earth orbiter conducted the first all-sky survey in the infrared in 1983, and the data are still being analyzed at the Infrared Processing and Analysis Center on the Caltech campus.

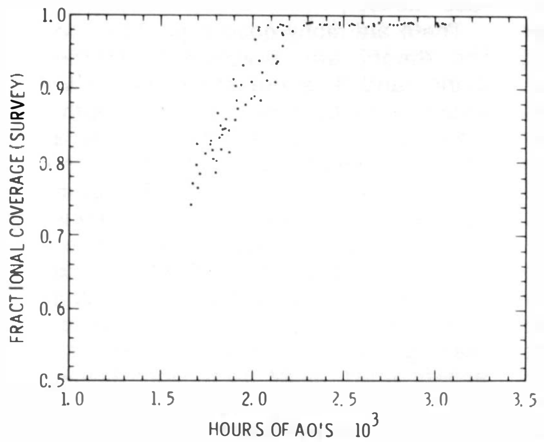
The primary objective of IRAS was, indeed, to complete an all-sky survey. A secondary, but very important objective, was to conduct special observations on selected objects of interests: star-forming regions, galaxies, etc. Therefore, at the highest level, one could characterize the mission by two numerical measures: (1) the fraction of the sky which was satisfactorily surveyed, and (2) the number of hours available for "additional observations." In both cases, of course, more is better.

Before launch we wanted to gain understanding as to our probability of achieving various possible results in these two categories. The mission performance would be driven by several quantities which were inherently uncertain: mission lifetime (when the supply of cold helium boiled off, all would be over); the influence of radiation hits on instrument performance; interference expected from the Moon; the time spent slewing from target to target; and several other factors.

Therefore, we decided to build a computer program, SKYDOT, to simulate via Monte Carlo the mission in advance of flight. The name of the program reflects the fact that its output was "dots" in a plane; each dot represented an outcome with a certain fraction of sky coverage and a certain number of additional observing hours. The uncertain parameters mentioned above were varied in a probabilistically reasonable manner before producing each "dot." (Once, for each case, exact values of the parameters were settled upon, the calculation of the two output quantities which defined a particular dot was a rather simple arithmetic process.)



The Monte Carlo method of probabilistic simulation was used to analyze aspects of the Infrared Astronomical Satellite (IRAS) mission prior to launch in 1983. Here, 100 possible outcomes of the results of the mission were probabilistically generated and displayed as "dots." Each dot shows what fraction of the celestial sphere was (for this case) successfully mapped (1.0 is best) and, at the same time, how many hours were left over for "additional observations" (more is better). The very successful IRAS mission achieved an outcome near the upper-right corner. NASA/JPL



A second Monte Carlo simulation was run for IRAS except that it was assumed our knowledge of uncertainties was better than for the first simulation. Hence the pattern of dots is somewhat more compact. The spread from lower left to upper right, which dominates the uncertainty, was largely due to not knowing how long the onboard supply of coolant (superfluid helium) would last. NASA/JPL

Now, it is time to praise Monte Carlo as a tool to facilitate the understanding.

For the IRAS case, the method permitted results to be obtained without having to develop an intricate analytical model, and this virtue is persistent in the genre. The output consisted of 100 dots describing 100 possible, probabilistically selected (i.e., generally plausible) cases. The number 100 was chosen so as to allow what I would call imaginative visualization: enough cases to be statistically significant but not too many to prevent one from looking at the dots and indulging in storytelling. "Look at that one. Great!" Or, "What went wrong (shudder) with that one?"

Monte Carlo treatments are one way to approach the age-old problem of how to act when only partial knowledge is available. Most of our actions are reasonably routine, and a plan of action, difficult through it may be to implement (e.g., go on a diet; study 12 hours per day), is usually clear. However, when uncertainties run deep, their resolution can appear so difficult that fanciful explanations are often invoked. The Oxford scholar Roger Bacon (1214-1294) was so skilled that it was reputed he had built a talking brass head to assist him. Similar stories were told about Albertus Magnus (1204-1282), and today astrology enjoys great popularity as a guide to the perplexed.

Thus, I enlarge the list of Monte Carlo's virtues by placing it, along with other branches of probability theory, on the front lines in the struggle of reason with unreason. This characterization is a stretch but not as odd as it might first appear if one recalls the tradition of the great poem of Lucretius (c.95-c.55 B.C.), *De Rerum Natura*, which seeks to remove fear arising from unreason.

I will share some lines from this poem with you. "And so it was that the lively force of his mind won its way, and he passed on far beyond the fiery walls of the world, and in mind and spirit traversed the boundless whole."

As an analysis of my essay style would show, I frequently add, at the end, some compressed sentiments analogous to the "moral tag" of Victorian poets or the surprise ending of a short-story written by such as O Henry (1862-1910). So, I was not surprised to see the last two paragraphs appear.

Although those lines constitute a serious rupture of continuity, I have let them stand because they furnish a glimpse of the important truth that there are some special mental tools, built over the ages, to aid clear thinking. Probability theory is one; Greek geometry was early in the lists. The second half of the truth is that there is a lot of nonsense in the world to be confuted, and, in addition to common sense and sound judgment, the special tools available to reason should be respected and, even, on occasion, celebrated.

Now, the ground has been prepared for a proper moral tag. Our guest aphorist is Samuel Johnson (1709-1784). "Truth, Sir, is a cow, which will yield such people no more milk, and so they are gone to milk the bull." ■

US Space Glasnost

Sir, In the article "NOTS Air-Launched Satellites" by Joel W. Powell (***Spaceflight***, November 1994, p.374), a flight chronology indicates that on 25 July 1958 and on 22 August 1958 two Notsnik rockets successfully reached orbit, although according to the sources used by Powell, it is uncertain that they did actually reach orbit, due to the primitive state of the contemporary tracking facilities and an inadequate telemetry system on the vehicle. While signals were heard by tracking stations on both orbital attempts, the signals were quite faint and Powell was forced on the available evidence to be inconclusive on the ultimate fate of these two vehicles.

However, in an article in *The Los Angeles Times* [1], Jon Nicolaides, who was technical chief of the Navy's space project, stated that on direct orders from the Eisenhower White House, the success of the rocket launches were never to be disclosed.

"It was not announced, as agreed upon by myself and the White House. I am saying that it did enter orbit now for the first time". Ultimately, the Notsnik rocket launches were hoped by the Navy to launch a reconnaissance satellite and anti-satellite satellite. Nicolaides further stated that although the reconnaissance and anti-satellite vehicles were not sent into orbit, they were built and tested at China Lake, California between 1958 and 1960.

In the same newspaper article, another China Lake Naval engineer by the name of Leo L. Keilman, said he did indeed build an anti-satellite spacecraft, and that is was prepared for launch into space at a Pacific Ocean test range but was destroyed by a rocket-motor explosion during the early seconds of launch. "It nearly landed on my head," Keilman is quoted as saying, referring to the wreckage raining from the sky. If Keilman's recollection is accurate, this means that in 1958 the USA was already preparing to conduct military missions in Earth orbit, and anti-satellite weapon development was already going full-bore about eight years earlier than similar Soviet efforts.

The China Lake engineers also started in 1958 to develop a spacecraft - that would use jet pulses for control - to ultimately photograph the far side of the Moon. However, the article does not state what the ultimate fate of this project was.

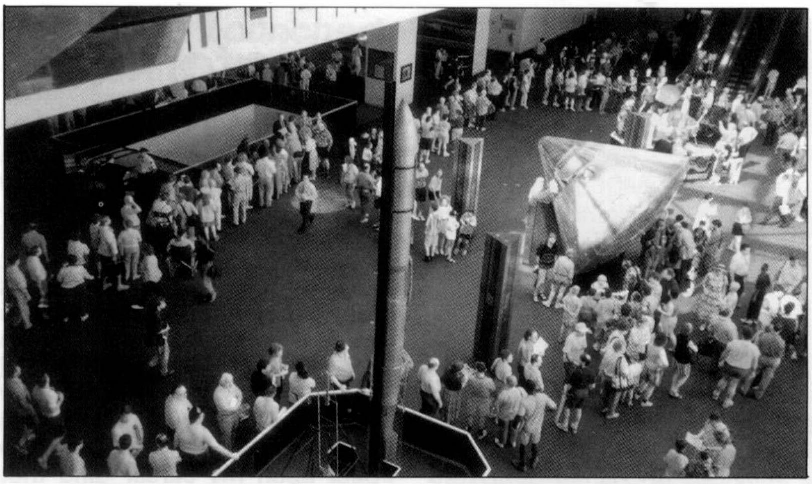
So, the official space log from mid-1958 should read as follows:

Sputnik 3 - 15 May 1958; Notsnik (orbital attempt #1) - 25 July 1958; Explorer 4 - 26 July 1958; Notsnik (orbital attempt #3) - 22 August 1958; Score - 18 December 1958.

PETER PESAVENTO
California, USA

Reference

1. R. Vartabedian, "One Last Transmission from Satellite Old-Timers", Los Angeles Times, 2 October 1994, pp.D-1, D-6.



Queuing for the lunar landing commemorative stamps, postmarked envelopes and autographs of Paul and Christopher Calle, the stamp's designers at the Smithsonian Institution National Air and Space Museum on 20 July.

Washington, DC Remembers Apollo 11

Sir, From 16-23 July I visited Washington, DC. The first lunar landing and reminiscences of a wide variety of people were the main topic on all television networks. Buzz Aldrin was a frequent visitor to a host of talkshows and breakfast interviews. Dave Scott gave a thrilling account of his experiences as a lunar astronaut.

The Smithsonian Institution's National Air and Space Museum was especially the place to do some celebrity-spotting. On 19 July former astronaut Alan B. Shepard was signing copies of *Moon Shot*, which he co-authored with Deke Slayton.

The next day the lunar landing was hot topic No. 1 again and it gave the younger of us a glimpse of how it must have been in that historic week back in 1969. The Smithsonian's Air and Space Museum opened its doors with a live broadcast presentation of two new stamps to commemorate the lunar landing.

After the presentation, long queues immediately started taking shape and almost symbolically the newly refurbished command module 'Columbia' was at the centre of the three queues.

These events evoked the spirit which led these men to the Moon. It can only be hoped that this anniversary will add some impetus to other exciting and interesting space projects in the future.

DR KRISTIAAN TEMST, FBIS
Leuven, Belgium

Apollo Look-Back

Sir Following the publication of my comments on the Kennedy assassination factor in the "Apollo Look-Back" feature (***Spaceflight***, October 1994, p.351), my friend Eddie Pugh, who also contributed excellently (and somewhat more extensively) to the feature, has suggested extending the hypothesis.

He points out that the assassination brought to the White House the one member of the Kennedy administration with a record of support for manned space exploration. Johnson, as he says in his contribution, deserves far more credit than Kennedy for sending Americans to the Moon.

Johnson was elected in his own right in 1964, but decided not to stand in 1968, (which he had the right to do, since at the time of Kennedy's assassination the remaining period of the term to which he had been elected, and which Johnson completed, was less than half a four-year presidential term).

As Eddie says, where would we be now if Johnson had stood in 1968 and won? Of course, Vietnam and other factors might have arisen, but what might have come about with an enthusiast at the helm?

RAY WARD
Sheffield, UK

Space on TV

Sir, European readers may be interested to know that space television programmes are shown nightly on a German channel available on the Astra satellite. The station is called Bayern Fernsehens and it is on channel 45 (11.141 GHz, Horizonal polarization). The programmes include Spacelab D2, Mir-92, Eureca and Ulysses in German and an overview of the Space Shuttle system and highlights of some missions in English. Broadcasts start at around 11.30 pm GMT on weekdays and 12.30 am GMT at weekends. They have been shown in a weekly cycle since 1 June.

May I thank the Society for organising the talk by Claude Nicollier which I enjoyed very much.

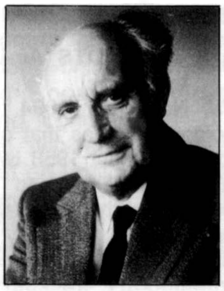
NEIL McLAREN
Oxon, UK

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

Philip E. Cleator

Founder of the British Interplanetary Society

It is with deep regret that we record the death of Phil Cleator who was instrumental in founding the Society in 1933. The Society extends its condolences to his wife in her loss and takes this opportunity to pay tribute to his life and work for the Society.



P.E. Cleator

CLEATOR BECAME the Society's first President and Editor of its printed Journal, the first issue of which appeared in January 1934.

His activities on behalf of the infant organisation entailed attending to numerous telephone and postal enquiries, travelling about the country interviewing new and prospective members and making trips abroad to confer with rocket experimenters in Germany and elsewhere.

He wrote articles on the prospect of space travel and delivered lectures on the subject, several of which were broadcast by him from radio stations as far apart as London, Capetown, Johannesburg, and Salisbury (Southern Rhodesia) - all such activities being hopefully undertaken "at the expense of the more mundane task of earning a living." He was a structural engineer and research contractor by profession.

His book *Rockets Through Space* was published in 1936. *Into Space* followed in 1953 and *An Introduction to Space Travel* in 1961. Passing references to rocket research and the interplanetary idea found mention in other titles, notably *The Robot Era* (1955) and *Weapons of War* (1967).

As a result of the close association he maintained with kindred organisation abroad, he was appointed British Delegate of the E.V. Fortschrittliche Verkehrstechnik (successor to the VfR), and was a Complimentary Member of the Cleveland Rocket Society and an Honorary Member of the American and Pacific Rocket Societies. In post war years, his name was entered in the *Ehrenbuch der Astronautik* by the Gesellschaft für Weltraumforschung, and on June 18, 1949, he was admitted to Honorary Fellowship of the BIS. His election as a member of the International Academy of Astronautics took place in 1985.

The early years of the Society's activities were centred at Liverpool and are customarily referred to as the 'Liverpool Era', which came to an end when the Society transferred its base to London in 1936. Dr L.R. Shepherd, who joined the BIS as an associate member during the Liverpool Era, writes below about Phil Cleator and the Society during those years.

Appreciation by Arthur C. Clarke, CBE

Though I met him only half a dozen times, Phil Cleator had a greater impact upon my career (and those of many of my friends) than almost any other man. By founding the British Interplanetary Society in 1933 (at the ripe age of 25) he changed the course of many lives.

It is now almost impossible, even for those who experienced it, to recall the ridicule with which the very idea of space travel was received in those days. I am indeed happy that Phil lived to see the vindication of his ideas - perhaps to a greater extent than he ever dreamed.

He was also a very prolific writer on other subjects; when he sent me his *Weapons of War* in 1967, he had already published ten more books, most of them on archaeology. His *Weapons of War* has a sad inscription - "To the memory of my parents: 12 March 1941." Their names are enclosed in the outline of a bomb...

I would like to send my sympathy to Madelon, his wife of more than half a century, who was his companion through his trials and triumphs.

Colombo, Sri Lanka
25 October 1994

Appreciation by L.R. Shepherd

Philip E. Cleator was born in Wallasey, Cheshire, in June 1908. As a young man, engaged in a family engineering contracting business, he had become interested in space travel and the growing activity abroad in rocket experimentation.

With rocket and spaceflight societies being established in several countries, following the lead of the VfR, Cleator expected that British scientists would also form such an association. In default of this happening, he decided to take the initiative himself. His efforts opened with his first article, "The Possibilities of Interplanetary Travel", published in Chambers' Journal in January 1933. This failed to attract the desired response and, after a lapse of several months, Cleator was prompted to approach the Editor of the Liverpool Echo with a copy of the Chambers' article

The outcome was an agreement that the Echo would publish an appeal for persons interested in spaceflight to communicate with him, with the object of forming a society devoted to the subject. The appeal appeared in the 8 September 1933 edition of the Echo, but to little avail, a single solitary reply resulting from it.

All was not lost, however, for Cleator's initiative came to the notice of the national press. As a result, a Manchester correspondent of the Daily Express was despatched to interview him. The journalist, N.E. Moore Raymond, was genuinely enthusiastic over the idea of setting up a space society and offered himself as a first member. He prevailed upon his editor to feature the proposal to set up a British Interplanetary Society on the front page of the Express. This was the critical point in Cleator's campaign. The Daily Express is a national newspaper and, at that time, it vied with its nearest competitors for the honour of having the highest circulation in the country. Not surprisingly, the front page feature led to a flood of replies and Cleator was able to arrange for a small gathering of interested local people at his home. There, the decision was taken to set up a British Interplanetary Society.

Following the gathering at Cleator's home, the inaugural meeting of the Society took place in Dale Street, Liverpool, on Friday 13 October (1933) when its formal foundation as The British Interplanetary Society was transacted. Philip Cleator was made President, C.H.L. Askham, a radio amateur, was appointed Vice President, L.J. Johnson became Honorary Secretary of the Society. The first task of the founder was to set out the purpose and objectives of the new association. It was recorded in its first publication - Volume 1 No. 1 of the ***Journal of the British Interplanetary Society (JBIS)*** - that, "The Ultimate Aim of the Society, of course, is the conquest of space and thence interplanetary travel", and it was further noted in the same issue that, "(the) immediate task is the stimulation of the public interest in the subject of interplanetary travel and the dissemination of the knowledge concerning the true nature of the difficulties which at present hinder its achievement".

In pursuit of this objective, of disseminating information, it was decided to publish a regular, properly printed Journal, initially, on a quarterly basis. Cleator was appointed editor. The first issue, dated January 1934, was no more than a small pamphlet; a humble precursor of today's ***JBIS***, which is arguably the world's oldest surviving astronautical publication. The publication objective was met, despite some financial problems, during the Journal's first year, with issues dated January, April, July and October, though the aggregate number of pages was only 38. In the subsequent years at Liverpool, however, only five more slim Journals were issued, with a total of 70 pages.

Cleator spared no effort in his attempts to build up the membership of the new society. In his own words [1], "I was the only member who was recklessly prepared to neglect the mundane matter of making a living in an all-out effort to place the Society on its feet... While others attended to the running of the Society in their spare time, I perspired over the preparation of public lectures, sought out and interviewed various people throughout the British Isles and most of Europe, and wrote lavishly for papers and magazines". In fact, Cleator did not lack support from the Press and through this medium was able to spread the news of the BIS. Perhaps the most effective publicity for the Society, however, came from Cleator's own book *Rockets Through Space*, published in 1936. This simple but excellent outline of the problems of rocket propulsion and space flight did much to arouse interest in the subject in Britain and, no doubt, was an important factor in recruiting members for the Society.

Cleator's campaign was not confined to Britain. In January 1934 he flew to Berlin to meet leading figures of the VfR, which by this time had ceased to function. An important contact in this excursion was Willy Ley, a noted figure in the field, who was instrumental in introducing Cleator to a number of distinguished pioneers in the subject, whom he was able to recruit to the BIS. These included Esnault-Pelterie of France, von-Pirquet (Austria), Perlmann and Rynin (USSR), as well as Pendray, the president of the ARS and A.M. Low (a well-known figure among those dedicated to the task of keeping the public informed of scientific developments) who was destined to succeed Cleator as President of the BIS.

For all Cleator's great efforts, the growth of membership of the BIS was modest, particularly when compared with that of the VfR. The Society went into 1934 with only 15 members and at the end of its first year the number had reached a meagre 56. The second year was not encouraging, with the rate of election falling to less than a half of that during the first. A significant boost in recruitment followed the publication of *Rocket Through Space*, in February 1936, but when the Society suspended operation in September 1939 at the outset of the Second World War, its total membership still fell short of 200 and only a minority of these were professional scientists or engineers. It was argued by some that the name and purpose of the Society was not sufficiently respectable to attract serious minded scientists and engineers to its ranks. After all, the possibility of flying to the Moon or other planets was regarded as pure fantasy by, perhaps, the majority of those in the scientific or technical professions, while those who had the vision to recognise the eventual possibility of space flight considered that it was probably too remote to attract their interest.

In 1934 "respectability" prevailed in the USA when the American Interplanetary Society stepped back from the brink and became the American Rocket Society. There was soon a move to follow that example within the British Interplanetary Society, but Cleator, with the support of most members, resisted this call, pointing out that the raison d'etre of the Society was to promote the achievement of "the conquest of space and, thence, interplanetary travel - however remote it may seem at the present", and not simply to research rocket propulsion. In the event, of course, Cleator's resistance to a down grading of the Society's objective was to be brilliantly vindicated and space flight was achieved on a time-scale that even the most ardent enthusiast could not have envisaged at that time.

The name, British Interplanetary Society, implied that the Society had things in the correct order and was concerned, first, in studying the objectives and then the means for achieving those objectives, namely, rocket propulsion.

By the Spring of 1936 events had moved in a way that presaged the end of the Liverpool era of the BIS. All was not well in the Merseyside government of the Society, considerable resentment of Cleator's domination of affairs being felt by his fellow officers. This came to the fore at a meeting in April 1936, when he was accused of taking upon himself most of the duties that should have been the prerogative of other officers, in particular, those of the Honorary Secretary. In fact the Secretarial Address, given prominence in most publications of the BIS, was the President's Wallasey address more often than that of the Secretary and there can be no doubt that the great bulk of the correspondence went to Cleator who dealt with it himself. The outcome of the meeting was that he relinquished all activities, including his duties as editor of the Journal and gave an undertaking to turn over all material, addressed to the Society, to the Secretary. It soon became clear that the Honorary Secretary and other Merseyside officers of the BIS were quite incapable of handling the volume of business which, up to that juncture, had been the routine duty of Philip E. Cleator.

The Liverpool-based Society was clearly doomed and the BIS had no real chance of survival in that environment. Paucity of members in the Liverpool region meant that there was no possibility of finding the support there needed to maintain the Society. Circumstances had changed with the growth of the BIS and the centre of gravity of the membership had moved South. The mainstream of the Society was now the Thames; the Mersey had become a backwater. In October 1936, a group of members in the metropolitan area met in the office of A.M. Low, who by this time had become a Vice-President of the BIS, to form a London Branch.

At a Special General Meeting on 6 December 1936 the Liverpool members acknowledged that (without Cleator) the task of conducting the business of the British Interplanetary Society was beyond them and they formally invited the London Branch to take over the government of the Society. Cleator, who had not been consulted in the transactions, immediately resigned the Presidency. The Liverpool Era was at an end.

In terms of communication to the public, technical or otherwise, the Liverpool era could be counted successful, a fact, however, that has to be attributed almost entirely to the efforts of the founder. The Journal itself was disappointing in so far as it had not maintained the regular quarterly publication status initially intended. However, the last two issues produced in Liverpool had progressed significantly in style and format from the first 8-page pamphlet of January 1934. The technical content of these Journals was slight and the Editor (Cleator) was frequently required to fill in. In this respect, it is appropriate to note that Philip Cleator had always demonstrated, in his writings, a remarkable gift of lucidity and a wry sense of humour which could well be the envy of less talented authors. Nowhere was this better demonstrated than in his classic book *Rockets Through Space*, which at the very least, must be described as eminently readable and absorbing. However, on the negative side, it is a legitimate criticism to remark that he was given to occasional departures from objectivity in his criticisms of governmental and other authorities, of public apathy, and of any individual or organisation that was less than fully enthusiastic about interplanetary travel. This, perhaps, was a negative aspect of his otherwise outstanding contribution to the making of the Society.

It was natural for Cleator to feel bitter about the transfer of government of the BIS to London where it would have been, effectively, out of his hands even if he had retained the Presidency, which would have been open to him.

In the event, he chose to resign while he was still at the top, though he graciously accepted the role of Vice-President, under the new London regime and was to participate in the early post-war government of the Society, serving on the Council from 1947/1951.

Philip E. Cleator need not have been disappointed about his place in the history of astronautics. The BIS was to play an important role in that history and Cleator's place of honour as its founder was assured.

27 October 1994

Reference

1. P.E. Cleator, Matters of No Moment, ***JBIS*, Vol 9**. No. 2, pp.49-53, March 1950

–Book Notices

The Millennial Project: Colonizing the Galaxy in Eight Easy Steps

Marshall T. Savage, Little, Brown and Company, 1271 Avenue of the Americas, New York, NY 10020, USA, 512pp, 1994, $27.95 Hardback, $16.95 Paperback, ISBN 0-316-77165-1.

This is a hardbound version of a book already reviewed (*Spaceflight*, August 1993, p.286). The author begins, uncompromisingly, with the assertion "It is our destiny to colonise space" and then submits ideas on how to undertake the task in eight stages which develop many of the themes also dealt with, e.g. in the Terraforming issues of *JBIS*, but adds that "Our life in Space will not be the barren or bleakly technical existence we have been led to believe. We will recreate all the beauty and diversity that we had on Earth".

After a short introduction, which sets out the time scale involved i.e. soaring freely among the stars within the next thousand years and with descendents populating the galaxy a million years from now, the author begins with a plan for building floating colonies in tropical waters to help to reverse the greenhouse effect and end world hunger, besides providing the psychological acceptance of a break with Earth. From thence he moves to orbital space colonies, adapting the Moon to provide a new habitable world, and then to terraforming Mars.

From that point on he embraces the whole of the solar system and leads on to the concept of colonising the galaxy.

Arthur C. Clarke, in his Foreword, both applauds the book and warns his fellow science-fiction writers to look to their laurels, less this new author steals their thunder.

Circumstellar Media in the Late Stages of Stellar Evolution

R.E.S. Clegg, I.R. Stevens and W.P.S. Meikle, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 345pp, £40, ISBN 0-521-46551-6.

How do low and high-mass stars interact with their immediate surroundings during the last throes of their lives? Or how do asymmetric stellar winds and the circumstellar medium affect the shape of a nebula? How are supernovae affected by a dense medium and what do we know about how stellar winds interact with their environments? These, and many other exciting issues, are addressed in these proceedings.

Highlights are the description of the latest observations, including those made with the Hubble Space Telescope, of stellar ejecta in planetary nebulae, novae, ring nebulae and supernovae, as well as the latest results on the media around supernova 1987A and 1993J. A unified view is given of the physical processes involved.

This timely volume of review articles serves both as an excellent introduction for graduate students and a handy reference to others, describing up-to-date research for those who want to keep abreast of developments in an exciting field.

Spaceflight in the Era of Aero-Space Planes

R.J. Hannigan, Krieger Publishing Co, PO Box 9542, Melbourne, FL 32902-9542, USA, 1994, 320pp, $69.50, ISBN 0-89464-046-1.

Transportation is the common denominator of human exploration so aerospace vehicles, which operate like aircraft but regularly fly to and from orbit, have the potential to bring space transportation more in line with terrestrial transportation.

Fundamental changes must take place if space is to become another domain of human activity. Enhanced management, wider international cooperation and stronger political leadership all play a part but, like all other major terrestrial activities, space has to achieve rational objectives to justify its cost in the public eye.

This book, based on recorded interviews with many of those intimately engaged in these projects, reviews the technological innovations and developments which have taken place since the 60s to bring up to date the tantalising concept of a single-stage-to-orbit vehicle. Many countries have made, or are endeavouring to produce, designs from which to build and test air-breathing hypersonic aerospace craft, though this book is not restricted to winged-air-breathing engine vehicles alone; it includes single-stage rocket craft such as the recently-tested Delta Clipper X1, which has neither wings nor air-breathing engines but is a lifting body.

The efforts of American, German, Japanese and other countries to develop air-breathing hypersonic space launch vehicles are analysed, and an examination made of the economic implications likely to stem from the introduction of such craft.

At a time of world pessimism and pressure on space programmes, there is hope that some of the younger generation will come forward to provide an answer to those who continually cry that space transportation is not only expensive, but always must remain so.

How spaceflight develops over the next century could, potentially, be profoundly different from that of today, for it is an uphill task to argue for bases on the Moon or outposts on Mars when the 1990s reality suggests that even a basic space station is complicated, takes many years to achieve and is exceedingly expensive, a matter compounded by increasing pressure on governments for budgetary restraint.

This suggests that building aerospace planes will prove mandatory if we are to bring about the first stages of human expansion into space. It seems evident that a significant, self-sustaining growth will prove unlikely without them.

The Vanishing Universe: Adverse Environmental Impacts on Astronomy

D. McNally, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 184pp, £50, ISBN 0-521-45020-9.

Observational astronomy in both optical and radio wavelengths is now suffering severely from environmental degradation due to causes ranging from electromagnetic pollution to near-Earth space debris. This review addresses such increasing problems and discusses the broader implications which flow from the effects of jeopardising ground-based astronomy.

Astronomy relies on the detection of weak cosmic signals so it is acutely vulnerable to environmental pollution. In that sense it acts as an early-warning system on the effect of pollutants. The book proposes various remedies. It demonstrates the success of some of the schemes already in place and outlines the legislation required if we are to regulate and monitor pollutants on an international scale.

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These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

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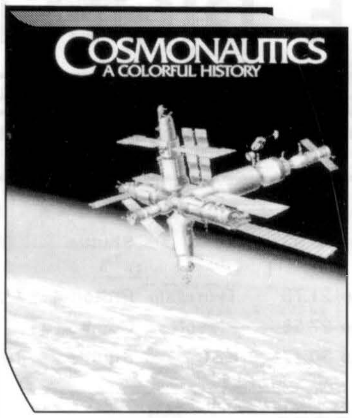
IMPORTANT ANNOUNCEMENT COSMOS TOURS has been designated as the official organization to coordinate the program for the launch of the (first) American astronaut (from Baikonur – the Russian "Cape Canaveral" to the Russian "Space Station") next March (1995). If you would like to be a member of the Official "American/International Delegation" attending the launch, please reserve your space ASAP as the size of the delegation is limited.



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Two Important Reference Volumes

The RAE Table of Earth Satellites, 1957-1989

1056 pages, published in 1990. Original price £85.

The Society has acquired the remaining stock of the RAE Table of Earth Satellites, a substantial volume originally published at £85 which it is now making available at the incredible price of £7.50 (US$15), plus postage and packing £4.50 in the UK, £9 (US$16) abroad.

The RAE specialised in the analysis of satellite orbits to determine the Earth's upper atmosphere density and winds, as well as its gravitational field. In order to choose suitable satellites, a listing was necessary, thus leading, over the years, to the present volume containing data on more than 17,000 satellites, including fragments, in 893 pages of tabulation. Extensive revisions have been made to this, the fourth edition, to include not only all new launchings to extend the period covered to 1989 but also to incorporate over 1,000 revisions to the earlier data.

DRA Table of Space Vehicles, 1958-1991

The Society has also acquired the remaining stock of the DRA Table of Earth Satellites, originally published for £30 and now available from the Society at £5 (US$10) post free.

This companion volume to the Earth Satellite Table runs to 113 pp and lists all 124 space vehicles to escape from the Earth over the 1958-1991 period. Data features the name and international designation of each spacecraft and its associated rocket(s), launch date, mass, shape and size and details of orbit or trajectory. Where appropriate the time and place of impact or landing on the Moon or planet are given.

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SATELLITE DIGEST-271

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, Worldwide Satellite Launches prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
TELSTAR 402	1994-058A?	Sep 9.02	Kourou	Ariane 42L	3,331	Orbital data not known					[1]
Discovery	1994-059A	Sep 9.93	KSC	Shuttle	95.671	Sep 10.15	57.01	89.71	254	266	[2]
SPARTAN 201	1994-059B				1,288	Sep 13.90	57.00	89.68	253	265	[3]
Cosmos 2291	1994-060A	Sep 21.75	Tyuratam	Proton-4	2,300 ?	Oct 1.07	1.53	1,436.13	35,758	35,817	[4]
Cosmos 2292	1994-061A	Sep 27.58	Plesetsk	Cosmos	500 ?	Sep 28.18	82.99	108.93	400	1,954	[5]
Endeavour	1994-062A	Sep 30.47	KSC	Shuttle	101,170	Sep 30.50	57.00	88.90	214	227	[6]

NOTES

1. TELSTAR 402 is a communications, television and data transmission satellite, built by Martin Marietta Astro Space for AT&T. Satellite planned for deployment over 271 °E. Contact was lost with TELSTAR 402 after a successful launch into geosynchronous transfer orbit, the loss of signal coinciding with the planned pressurisation of the satellite's propellant tanks. Some reports suggest that the satellite disintegrated in orbit. USSPACECOM has only tracked one object from the launch (1994-058A/23249) which has been nominally assigned to the satellite: however if the satellite did disintegrate then it would be reasonable if the tracked object were to be the intact Ariane third stage since debris from a disintegrated satellite would be difficult for USSPACECOM to track in a geosynchronous transfer orbit.
2. Six astronauts carried aboard the shuttle STS-64 mission: R.N. Richards (commander), L.B. Hammond Jr (pilot), J.M. Linenger (mission specialist, MS-1), S.J. Helms (MS-2), C.J. Meade (MS-3) and M.C. Lee (MS-4). Mass quoted above is that projected for landing which took place September 16.88 at Edwards Air Force Base.
3. SPARTAN 201 was deployed from the shuttle payload bay September 13.90 and recovered September 15.88 after an independent flight, undertaking solar studies.
4. Geizer communications and data relay satellite, launched as part of the Potok system. Believed to be used primarily for military applications. Orbit stabilised over 80 °E.
5. Satellite flown for passive monitoring of the Earth's upper atmospheric density.
6. Carries six astronauts for STS-68 mission: M.A. Baker (commander), T.W. Wilcutt (pilot), T.D. Jones (payload commander and mission specialist, MS-4), S.L. Smith (MS-1), D.W. Bursch (MS-2) and P.J.K. Wisoff (MS-3). Mass quoted above is that projected for landing. Main payload is SLR-2 (Space Radar Lab), mass 10,794 kg, which remained in the shuttle's payload bay.

ADDITIONS AND UPDATES

1994-042A Cosmos 2283 was de-orbited during 1994 September 29-30.

1994-049B Add the following orbital data for Turksat 1B: September 13.18, 0.04°, 1,435.98 minutes, 35,779 km, 35,790 km. The orbit has the satellite located over 42 °E.

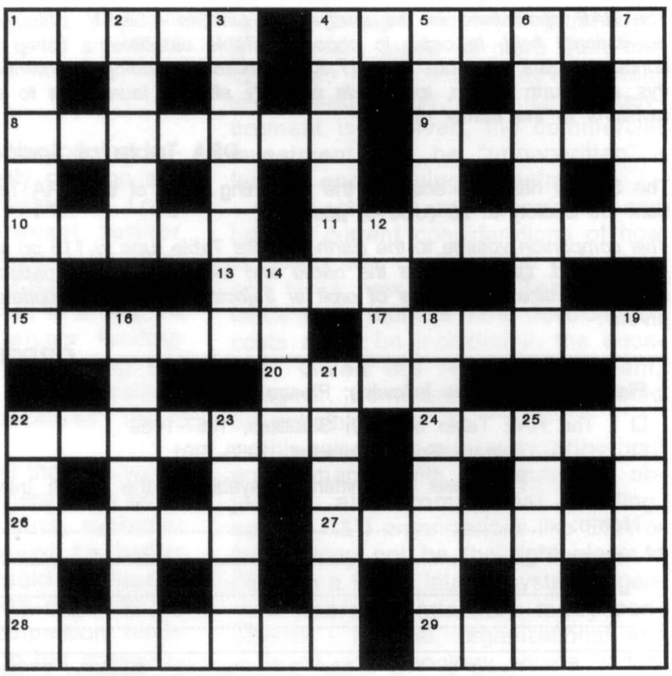
1994-052A Add the following orbit for Progress-M 24 after it docked at the rear of the Mir Complex: September 7.82, 51.65°, 92.69 minutes, 395 km, 398 km.

Spaceflight Crossword

No. 16

ACROSS
1. Pertaining to the Sun
4. Least
8. Hubble Repair Mission astronaut
9. Asteroid
10. Indian satellite series
11. Resistance wire in electric heater
13. Area of fluid in circular motion
15. Frozen Arctic plain
17. Repeat recording
20. Back end
22. Factual statements
24. Dangers
26. Enumerate
27. Based on the number eight
28. Rule of action
29. Criterion

DOWN
1. Type of telescope
2. Elevates
3. More distant
4. Provided with human operators
5. Stars that suddenly brighten
6. Mistake with handling cards
7. Intended
12. Northern constellation
14. Small pointed missile
16. Planet
18. Uncertain in movement
19. Letter of Greek alphabet
21. Accompanying person
22. Restatement of the main points
23. Fasten again
25. Cardinal number



Solution will appear in the January issue.

Solution to Crossword No.15.
ACROSS: 1. Visual; 4. Binary; 7. Parabolic; 9. Turf; 10. Lour; 11. Sends; 13. Region; 14. Seemly; 15. Prawns; 17. Turner; 19. Datum; 20. Lime; 22. Bean; 23. Exchanger; 24. Sextet; 25. Ladder.
DOWN: 1. Vector; 2. USAF; 3. Leaden; 4. Broods; 5. Nail; 6. Yearly; 7. Programme; 8. Commander; 11. Sound; 12. Serum; 15. Pallas; 16. Sachet; 17. Tunnel; 18. Ranger; 21. Exit; 22. Bend.

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SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in ***Spaceflight/JBIS*** or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

7 December 1994 — 7 - 8.30 pm

Collision of Comet Shoemaker-Levy 9 with Jupiter

Prof. I.P. Williams,
Queen Mary and Westfield College, University of London

The comet impact with Jupiter provided the world with a spectacular event, images of which were reproduced on Television and the Press. The talk will show many of the images and give an overview of new results relating to the dynamics of orbits, the structure of SL9, the composition of SL9, the atmosphere of Jupiter and the structure of the planet.

1 February 1995 — 7 - 8.30 pm

Great Balls of Ice - The Satellites of the Outer Planets

Dr David A. Rothery,
The Open University

The giant planets have considerable families of satellites, all icy except Io. Counting Pluto and Charon, there are 18 icy bodies large enough to have assumed spherical shapes (>200 km radius). Although their outer regions are icy, the processes that occur upon and within them mimic the geological processes, such as volcanism and tectonics, with which we are familiar on terrestrial planets.

5 April 1995 — 7 - 8.30 pm

Alternative Space Launch Concepts

Colin Jack,
Oxford Mathematical Designs

Launching orbital payloads by rocket costs upwards of £4,000/kg. Many potentially cheaper ways have been suggested, ranging from the plausible to the fantastic. But how to tell which is which? Can we rely on the judgement of the big space agencies? Colin Jack will be discussing the proposals, and trying to pick some winners. Suggestions from the floor will be welcome!

3 May 1995 — 7 - 8.30 pm

Cassini/Huygens Project

Dr John Zarnecki
University of Kent

The Cassini Huygens mission to Saturn and Titan will be one of the major missions of space exploration of the next decade. The mission will be described with emphasis on ESA's contribution, the Huygens Probe, which will land on the surface of Saturn's largest moon Titan.

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

Call for Papers for a Special Issue of JBIS

The pioneering role of the Society during its first 60 years of existence provided many new space concepts that significantly influenced subsequent astronautical developments.

The Society is now set to continue in this traditional pioneering role and, on the recommendation of its Advisory Committee on Science and Technology, the Council has adopted a project of wide interest and appeal. It has the theme title:

Vision 60 Plus

and its aim is to identify and review anticipated space developments over the next 60 years or more that will significantly affect the course of human progress and thought.

Preliminary guidelines have been established that offer the widest scope for contributions from the sciences, technology and sociology on a world-wide basis. Contributors can expect support from the review and presentation procedures offered by the Society's programme of publications and meetings.

*To be a participant in **Vision 60** Plus please notify the Executive Secretary of your interest and receive a copy of the Guidelines.*

The first steps of ***Vision 60* Plus** are already underway with the preparation of a special issue of ***JBIS*** for which a number of papers are in preparation and for which a **Call for Papers** is now being made.

Intending contributors to the ***Vision 60* Plus** issue of ***JBIS*** should send details as soon as possible to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England.

Welcome to 1995

New Year Society Get-Together with Patrick Moore

at the

SCIENCE MUSEUM
Exhibition Road, London SW7
on 19 January 1995, 6.30 - 8.30 pm

- ***Refreshment Buffet***
- ***Private Opening of Space Gallery***

The Science Museum opens its doors to BIS Members offering the opportunity to meet others and view the exhibits.

For tickets, price £7.50 (incl refreshments), send to the British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ. Members may obtain a ticket for one guest subject to availability of space. Early application is advised.

JBIS

The December 1994 issue of the Journal of the British Interplanetary Society is now available and contains the following papers on the theme of:

Lunar Industrialization and Colonization

The Fourth Wave
•
Lunar Industrialization and Colonization: Towards a Policy Framework
•
Dual Use Technology and Near Term Lunar Exploration: The Clementine Program
•
Lunar Industrialization: How to Begin?
•
Economic and Policy Issues for Lunar Industrialization
•
Evolutionary Scenario of Lunar Manufacturing
•
Role of Mining in Lunar Base Development
•
Commercial Activities Resulting from a Lunar Base

Copies of JBIS, priced at £17.50 (US$32.00) to non-members, £5.00 (US$9.00) to members, post included, can be obtained from the address below. Back issues are also available.

The British Interplanetary Society
27/29 South Lambeth Road, London SW8 1SZ
England.

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